Mapping the Complexity of Forensic Science: Implications for Forensic Science Education

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ABSTRACT

Over the past two decades the field of forensic science has experienced a remarkable development and a substantially enhanced public profile. The prominence of forensic science has resulted from scientific and technological advances, increased reliance of law enforcement agencies and judicial systems and its popularisation through the mass media. Consequently, forensic science education has been characterised by a rapid expansion in both the number of forensic science courses and the number of students enrolling in such courses. However, very little is published on forensic science education. This research aims to identify how best to organise and deliver forensic science education. By doing so, the research aims to generate graduates who are more proficient and with the knowledge and expertise needed for them to cope with the technological advances revolutionising forensic science and with ongoing security demands and challenges.

In order to meet its aim, the research has investigated forensic science education from its determining factors: forensic science knowledge, practice, and identity. The research adopted a qualitative approach to undertake the investigation. A document analysis of the published curricula of 190 forensic science academic programs offered worldwide produced an overview of the current status of forensic science education. Secondly, the research employed semi-structured interviews with a number of forensic science educators, forensic science practitioners, and members of professions associated with forensic science about their conceptions of forensic science knowledge, practice, and identity. This outcome of the methodology has been the proposition of critical features relating to the nature of forensic science. These critical features have become the basis for a consideration of the form of forensic science education.

The study identified four zones of knowledge within forensic science. These zones showed ontological connections with the segmented nature of forensic science practice and the cultural conflict existing within the field. The study found that the current reigning paradigm of forensic science is the result of an incomplete shift from an old explicitly policed reigning paradigm towards a new explicitly scientific reigning

paradigm. The research has led to the proposition of a set of curricular and pedagogical markers which reflect the nature of forensic science and respond to the epistemological and ontological challenges existing within the forensic science field.

Student Declaration

"I, Ahmad Nabil Samarji, declare that the PhD thesis entitled 'Mapping the Complexity of Forensic Science: Implications for Forensic Science Education' is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

Ahmad Nabil Samarji
Ahmad Samarji
21st December, 2010

First & Last, All Praises unto Allah, the Almighty, for His guidance, for providing me with the effort and the patience to conduct this research to completion... for everything

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To my Mother, Ghazwa, the most precious person in my life,

To my Father, Nabil, my role model and great support,

To my Sisters: Rima & Zeina,

To my Brothers: Tarek, Omar, and Ahmad el Hakeem,

To my Grandmother, Najda, the blessing of our family,

To my Aunty Raoha, the aunt, the sister, and the best friend,

To my Uncle Barrack, the uncle, the brother, and the best friend,

With love,

Ahmad Samarji

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Chapter 1: Introduction

1.1- The Subject of the Study

Over the last two decades, forensic science has emerged as one of the fields of study in academia with hundreds of universities and colleges worldwide offering forensic science programs (Quarino & Brettell, 2009; NIFS[1], 2006). The high profile that forensic science has enjoyed is mainly attributed to two major factors. The first is the “immense” need by the criminal justice system for forensic laboratory services, majorly forensic DNA profiling (NIJ[2], 1999). Such a need urged the expansion of these laboratory services, which in turn created new forensic science positions to be filled by individuals with the essential skills and science education specifically in the areas of chemistry, biology, and biochemistry (Quarino & Brettell, 2009).

The second factor is the media concentration on forensic science especially the “CSI” show and its “sibling” programs (Smallwood, 2002; Kobus & Liddy, 2008). Media concentration has resulted in the public developing ‘a fascination with and respect for science as an exciting and important profession unseen since the Apollo space program’ (Houck, 2006:5). Public interest in these shows has reflected on forensic science education to an extent where Max Houck, the project director of the Forensic Science Initiative at West Virginia University, remarked: ‘every third person on the planet wants to be a forensic scientist’ (Smallwood, 2002:1).

As a result, forensic science education has enjoyed an exponential increase in both the number of forensic science programs offered worldwide, and the number of students enrolling in these programs (Houck, 2006; Mennell, 2006).

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[1] NIFS= National Institute of Forensic Science(Australia)

[2] NIJ= National Institute of Justice (USA).

This substantial increase in forensic science programs in academia suffers from arbitrariness and randomness. Some forensic science programs are well organised, where the curricula of these courses are structured, content is delivered in close collaboration with industry, and graduates are often employed by forensic science centres or law enforcement agencies. On the other hand, a number of forensic science programs are randomly organised, where the curricula of these courses are unstructured, content is delivered in isolation from industry, and graduates are not sought after by forensic science agencies.

Conferences and committees worldwide (e.g. international symposia organised by the ANZFSS[3], reports and studies conducted by BAFS[4], FSS[5], NIJ[6], NIFS[7]) have called for a review of current forensic science academic programs in attempt to organise forensic science education, liaise it with the forensic science industry, and develop it to meet forensic practitioners' requirements and needs.

This research examines forensic science education from two perspectives:

a) The current status of forensic science education as reflected by the published curricula of forensic science courses/programs offered worldwide, and

b) The perceptions and informed opinions about the nature of forensic science and its education held by a number of forensic science educators, practitioners, and members of associated professions.

The research aims from such an examination to generate a comprehensive and thorough understanding of the ontological and epistemological nature of forensic science, in an attempt to identify implications for forensic science education. The research will provide a window into how possible forensic science courses could be

[3] ANZFSS= Australian and New Zealand Forensic Science Society

[4] BAFS= British Academy of Forensic Sciences

[5] FSS= The Forensic Science Society (U.K.)

[6] NIJ=National Institute of Justice (U.S.A.)

[7] NIFS= National Institute of Forensic Science (Australia)

structured, leading to the graduation of more knowledgeable and effective forensic scientists, thus, benefiting forensic science educators, forensic science practitioners and the associated groups who rely on forensic science practice.

1.2- Forensic Science: A Field under the Microscope

The field of forensic science has always incorporated complexities and controversies throughout human history from Napoleon's poisoning (1821) to O.J. Simpson's case (1994), passing by 'Australia's forensic nightmare', the Lindy Chamberlain case (1980s), and many other cases (Evans, 2003:172). 'The evolution of forensic science has been a long, complex, and fascinating journey' which has incorporated not only stories of triumph, but also stories of failure in the 'never-ending battle to close the loopholes through which criminals slip' (Evans, 2003:1).

Forensic science is a 'critical and integral part' of the judicial system, because forensic science is one of the primary means through which 'democratic governments fulfil one of the most fundamental obligations to their citizens: public safety insurance in a just manner' (Houck, 2006:5). Forensic scientists are obliged to work with very high professionalism within minute margins of error, if any. The evidence that a forensic practitioner might find on a crime scene, might be the only clue that was mistakenly left over by a predator and that might have survived contamination or harsh environmental conditions. Therefore, forensic scientists' practice is so critical and important as one piece of evidence may have the potential to change juries' deliberations and judges' sentences from guilt to innocence or vice versa. In this respect one study revealed that 'about one quarter of the citizens who had served on juries which were presented with scientific evidence believed that had such evidence been absent, they would have changed their verdicts- from guilty to not guilty' (Peterson, Ryan, Houlden & Mihajlovic, 1987:1748).

The importance of physical evidence has dramatically increased within the judicial system over the past two decades for many reasons some of which are: 1) the improvements in discriminatory power of the methods employed by forensic practitioners, 2) the increased scrutiny on experts' interpretations and testimonies as their opinions are now 'generally based on more objective and verifiable measures', and 3) the recognition by the organs of the law of the 'relative unreliability of eyewitness evidence which rarely approaches the standards of good physical evidence, such as DNA profiles which are capable of revealing facts independent of memory shortage and many other human psychological and physiological complications' (Liverpool John Moores University, Electronic[8]).

Forensic science nowadays is required to 'answer questions of interest to the justice system' and 'in the security space' (Robertson, 2008:5). Over the last decade, forensic science has been experiencing an increased pressure from governments as a result of the emergence of terrorist activities in addition to everyday homicides and criminal offences. This pressure on forensic science is often experienced consequent to events as large and shocking as the recent terrorist acts (London Bombings in July 2005, Assassination of Former Lebanese Prime Minister Rafic Hariri in February 2005, Madrid Bombings in March 2004, and World Trade Centre Bombing in September 2001), or as personal, yet shocking, as The Wee Waa Case, the sexual assault of an old woman in her 90s in a small town in New South Wales, Australia. In such cases, forensic practitioners, through seemingly unending work hours, have worked not only with victims, corpses, and human remains to identify the manner and cause of deaths or assault, but also with the community, including victim's families and friends, who attach great significance to human life and wellbeing (James & Nordby, 2005).

Despite the importance forensic science has gained on both governmental and public levels, and the expansion within higher education it has achieved as a result (Kobus & Liddy, 2008; Mennell, 2006), forensic science academic programs are characterised by a great deal of randomness and uncertainty. Forensic science suffers a non-consensus within the academic community on whether it is a stand-alone and distinct applied field of knowledge, an associate field of study, or merely a technical derivative of existing

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8 http://ljmu.ac.uk/MKG_Global_Docs/forensic_science_and_criminal_justice_bsc_joint_award.doc, Accessed:09/09/2006.

fields. Moreover, some scholars argue in the extreme whether or not forensic science education is a necessity at all within higher education.

This chapter explores in depth forensic science definitions, landscape, history, and prominence within media. Chapter One then addresses forensic science education, emphasising the various factors impacting such education. Finally, Chapter One identifies the research problem and addresses the research questions which are likely to propose solutions for the research problem when answered.

1.3- Forensic Science: Definitions and Landscape

1.3.1- Definitions

The word 'forensic' is derived from the Latin word *forensis* (Cassell's Latin Dictionary[9], 1987: 713) meaning:

- 'of, belonging to or inhabiting the forum' (Oxford Latin Dictionary, 1971:721), where the word forum is 'where the law courts of ancient Rome were held' (Camenson, 2001:1).

- 'public discussion, argumentative, rhetorical', giving the opportunity to debate or discussion (AAFS[10], Electronic).

- 'used in courts of law' (Fridell, 2007:6);

The word "forensics" means 'the art or study of formal debate; argumentation' (The American Heritage® Dictionary, 2006). However, the word forensics has been very closely associated with the scientific field to the extent that many dictionaries nowadays interchangeably use "forensics" and "forensic science" (Camenson, 2001). The Oxford English Dictionary records that one of the first uses of the phrase "forensic

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[9] Cassell's Latin- English & English-Latin Dictionary

[10] AAFS: American Academy of Forensic Sciences, http://www.aafs.org/default.asp?section_id=aafs&page_id=about_us, Accessed: 08/03/07

science" was to describe it as "a mixed science" (Oxford English Dictionary, 2005).

Nowadays, forensic science is defined as:

- 'Science as it pertains to the law' (Tilstone, Savage & Clark 2006:161).
- 'Science used in public, in a court or in the justice system; any science, used for the purposes of the law' (AAFS, Electronic[11]).
- Science that is 'pertaining to, connected with, or used in courts of law' (Camenson, 2001:1).
- 'The application of the techniques of science to legal matters, both criminal and civil' (Bell, 2004:142).
- 'A blanket term for many fields and disciplines, all related to the application of science to law enforcement and to any matters that are the subject of litigation'(Eastern Washington University, Electronic[12]).
- 'A broad term that embraces all of the scientific disciplines that are utilized in investigations with the goal of bringing criminals to justice' (Nickell & Fischer, 1999:1).

1.3.2- Landscape

Forensic science is a very broad field as any science or piece of knowledge used to assist in resolving a legal issue or case can enjoy the adjective 'forensic' in such context (Robertson, 2002). Complementing Robertson, Keith Inman and Norah Rudin assert that, as a field, forensic science is very broad because 'any profession, discipline,

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[11] http://aafs.org ,Accessed: 08/03/2007

[12] http://chemistry.ewu.edu/forensics/html/what_is_fs_.html, Accessed: 01/09/06.

craft, or art may potentially be invited into the legal arena' (2001:1). Forensic science employs physical, biological, medical and even behavioural sciences to examine, analyse and evaluate physical evidence (biological and non-biological), human beings (victims and suspects) and even trace evidence (e.g. pollutants in air) to matters pertaining to law (University of Illinios Chicago, Electronic[13]). Unlike what some may perceive, forensic science is not restricted to criminal law matters and criminal cases. Its landscape expands to cover civil laws and cases (Bell, 2004). For example, forensic science deals with family litigation (e.g. cases of paternity proof), environmental issues (e.g. suspected source of pollution or contamination) and other security legislation (e.g. custom check). The term 'criminalistics' is often confused with forensic science; however, criminalistics is 'the largest subdivision of forensic science' that encompasses the collection, preservation, and analysis of physical evidence by applying the laws of physical sciences and natural sciences (Bell, 2004: 142).

In its broadest sense, forensic science encompasses a large number of different disciplines some of which are addressed in Table-1A (definitions and descriptions of the disciplines listed in Table-1A are attached in Appendix A).

Because forensic science is a broad field, it is nearly impossible to conceive such a field of study that comprises all these underpinning disciplines, applications and specialisations. Therefore, this research will focus on a **working definition** of forensic science that is confined to the application of physical sciences, biological sciences, and other uniquely forensic forms of inquiry and techniques (e.g. crime scene processing, fingerprinting, etc) to matters relating to both criminal and civil law. In other words, the working definition of forensic science will be limited to criminalistics. Hence, it will exclude many other areas related to the forensic science field such as forensic pathology, anthropology, odontology, entomology, psychiatry, computing, accounting, etc. The confining of the working definition will simplify the conduct of this research. However, it cannot ignore the epistemological complexity of forensic science which will be a challenge for any university forensic science course.

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[13] http://www.uic.edu/pharmacy/depts/forensicsci/forensicsci.html, Accessed: 21/08/2005.

Disciplines which Fall within the Landscape of Forensic Science	
Pure Sciences	**a. Chemistry (Bell, 2006; Genege, 2002)** **b. Biological Sciences (Butler, 2005; Gunn, 2008; Robertson, 2004)** **c. Mathematics (Lucy, 2005)** **d. Physics (Wilkinson et al., 2002)**
Science Applications	**a. Forensic Pathology (Eckert 1997; Houck & Siege 2006)** **b. Toxicology (Houck & Siege, 2006)** **c. Forensic Nursing (Camenson, 2001)** **d. Forensic Anthropology (Katzenberg & Saunders, 2008; Platt, 2003)** **e. Forensic Archaeology (Chicora, 2003; Ferllini & Wecht, 2002)** **f. Forensic Entomology (Gennard, 2007; Greenberg & Kunich, 2002)** **g. Forensic Odontology (British Association for Forensic Odontology, 2002)** **h. Forensic Geology (Eckert, 1997)** **i. Forensic Computing (Camenson, 2001; Vacca, 2002)** **j. Forensic Engineering (Houck & Siege, 2006)** **k. Forensic Accounting (Bell, 2004)** **l. Forensic Economics (Camenson, 2001)** **m. Forensic Psychiatry & Psychology (Eckert, 1997; Houck & Siege, 2006)**
Uniquely Forensic Forms of Inquiry	**a. Crime Scene Investigation (Bell, 2004; White, 2004).** **b. Fingerprinting (Tilstone et al., 2006; White, 2004)** **c. Footwear and Shoeprints (Bodziak, 2000)** **d. Questioned Document Examination (Kelly, 2006; White, 2004)** **e. Tool Mark Examination (Kiely, 2006)** **f. Photography and Imaging (Blitzer & Jacobia, 2002; Russ, 2001)** **g. Firearms and Ballistics Examination (Bell, 2004; Rinker, 2005).** **h. Arson (Bouguard, 2004)** **i. Explosives (Yinon, 1999)** **j. Other Forensic Applications: Ear print identification, Voice Identification and Speech Analysis, etc (Geradts & Sommer, 2006)**

Table-1a

1.4- Forensic Science Development and Education through History

The history of forensic science may be classified into three periods (Eckert, 1997; Gerber & Saferstein, 1997; Evans, 2006). The first period was prior to the first half of the nineteenth century. This period incorporated minor forensic science events and activities. The second period extended from the second half of the nineteenth century to the first half of the twentieth century. This period was characterised by the interest in the identification of individuals using physical means. Such interest led to a number of major developments in forensic science. The third period extends from the second half of the twentieth century up until present. This period is considered to be the critical phase for the emergence of forensic science as a scientific field playing a major role in law enforcement.

1.4.1- Period 287 BC- 1850 AD

The first documented code of law that governed the practice of medicine goes back to Hammurabi, king of Babylon, around 2200 BC. In ancient Rome following his assassination in 44 BC, Julius Caesar's body was examined by a physician (Tilstone et al., 2006). In the period 287-212 BC, Archimedes, by using the principles of water displacement to examine density and buoyancy, was able to identify a fraudulent crown that was claimed to be made up of gold. A Chinese scientist, in 1284, was the first to describe how the cause of death alters the appearance of a body (Platt, 2003). In 1609, the first serious work on systematic document examination was published by the French Francois Demelle (Inman & Rudin, 2001). The first medico-legal journal was published in Berlin in 1782 (Tilstone et al., 2006). In 1814, Mathieu Orfila published the first scientific article on poison detection (Trimm, 2005).

1.4.2- Period 1851- 1950

During the second half of the 19th century, there was a considerable interest in trying to identify individuals using physical evidence (White, 2004). In 1879, Alphonse Bertillon, a French police statistics clerk, invented the world's 'first codified system of human identification' that is based on the hypothesis that 'no two humans-not even identical twins- looked exactly alike (Evans, 2006:1). He published his findings in his first book on anthropometry (Trimm, 2005). Bertillon's identification hypothesis was based on anthropologic measurements and calculations and was supported by photographic documentation (Eckert, 1997). Bertillion's technique had been adopted to arrest offenders for a period until 1894, when it was proven to be inaccurate and to incorporate some fatal errors (Evans, 2006). In 1892, Sir Francis Galton, an English scientist, was the first to devise a method for fingerprint classification (Platt, 2003). Galton published these findings in his book *Fingerprints* which aided police in using fingerprinting as a mean of identification after Bertillion's system of identification was abandoned as a result of a very famous case which proved that it is possible for two different people to have the same anthropometric measurements (Trimm, 2005). Fingerprinting has proved thereafter to be one of the arguably unique and more precise method of identification in the forensic science field (Eckert, 1997).

During this period, two German scientists, Karl Landsteiner and Paul Uhlenhuth, conducted experiments on the ABO blood grouping system and blood origin (White, 2004). These experiments on blood nature and type led to substantial advances in crime fighting (Evans, 2006). In 1893, Hans Gross, an Austrian scientist published the world's first treatise in criminalistics which was considered to set the fundamental guidelines for criminal investigation. Gross' work was later translated into English. The English version of Gross' work *Criminal Investigation* was issued by John Adams and J. Collyer Adam in 1906 (Gerber & Saferstein, 1997). In 1910, Edmond Locard, a French scientist, established a crime laboratory at Lyon Police Department. Locard is regarded as the "father of forensic science" because he was able to define an ontological foundation for forensic science, particularly his famous guiding forensic science principle: "Every contact leaves a trace" (Trimm, 2005: 5).

Until the 1930s, there were neither boards of review and examination, nor organisations to provide public discussions for the exchange of forensic related data and information. In 1930 the first forensic science journal was initiated: *The American Journal of Police Sciences* (Gerber & Saferstein, 1997). Until the 1950s, there was little opportunity for formal education and training in any of the fields associated with forensic science. The first academic legal department was set up at Harvard University after World War II had finished. The majority of forensic work undertaken by chemists or medical practitioners was usually on an ‘ad hoc’ or ‘extracurricular basis’. Curricula and pedagogies that organised education in the field of forensic toxicology were random and disorganised to the extent that students had to search hard themselves for a suitable course if they wished to pursue a career in forensic toxicology (Gerber & Saferstein, 1997).

1.4.3- Period 1951- present

In the second half of the twentieth century, Paul Kirk, an American criminalist, published *Crime Investigation* in 1953. This book is considered one of the first inclusive criminalistics and crime investigation publications which covered both theory and practice (Inman & Rudin, 2001). As a result of his substantial contributions, Kirk is considered to be the “father of criminalistics” (AAFS: Electronic[14]). In the same year (1953), James Watson and Francis Crick reported the structure of DNA (Edelson, 1998)**.** In the period between 1960- 1975 much research was conducted on blood and blood stain related issues and related protocols were set up as a result. Since the 1970s, analytical chemistry has progressed to become more responsive to biological inquiries after being explicitly dedicated to chemistry (Bell, 2006). Such progress was one of the major contributors in the development of the different areas of forensic science, particularly forensic chemistry and biology (Laitinen, 1989).

In 1985, Sir Alec Jeffrey, a British geneticist, discovered a method for DNA profiling which was one of the most important revolutionary turning points in the forensic science field (Butler 2005). In 1986, DNA profiling was used for the first time to exonerate an innocent suspect and identify the murderer of two young girls in the English Midlands (Inman & Rudin, 2001). In 1989 in the U.S.A, Gary Dotson became the first person in history who was proven innocent from a rape case after his conviction had been overturned on the basis of DNA evidence (Butler, 2005).

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[14] http://www.aafs.org, Accessed: 08/03/2007.

From the 1990s until the present, forensic science has advanced through developments in the scientific techniques which can be applied within forensic science, particularly the techniques of molecular biology and analytical chemistry (Butler, 2005). Advances in DNA technology- which mainly resulted from developments in analytical biochemistry- made DNA profiling more practical and reliable (Inman and Rudin, 2001). During this period, forensic science also enjoyed the establishment of computerised national databases for fingerprints, DNA, and ballistics in many countries such as United States, United Kingdom and Australia. This facilitated the way evidence, profiles, and prints are stored, searched for and examined (Tilstone et al., 2006). Scientific and technological advancements in forensic science have also impacted education and training in this field. Since the 1990s, the number of higher education providers which offer forensic science courses/programs have steadily increased in the USA, UK, Australia and many other countries (Mennell, 2006; NIFS, 2006).

1.5- Forensic Science in Public

Forensic science thrives by ‘embracing human intrigue and frailties, great mysteries and tragedies, and scientific triumphs and disgraces’ (Bell, 2008:1). Instances such as the O.J. Simpson’s Case and the Chamberlain’s Case made the public aware of forensic science. In addition, crime scene investigation shows such as the “CSI” show are often how the public learn about forensic science (Tilstone et. al., 2006). The general public has shown increased interest in forensic science and formed various perceptions of forensic related issues mainly through:

a) Stories and Novels: Forensic science has always been ‘the backbone of mystery stories’ from Edgar Allan Poe’s Dupin adventures (Houck, 2006: 84) to Sir Arthur Conan Doyle’s Sherlock Holmes tales (Trimm, 2005), to the bloodied crime scenes in Agatha Christie novels (Genge, 2002) and many others.

b) Media: The high profile forensic science has gained is mainly attributed to the prominence given to forensic science practices in the media (SEMTA[15], 2004). Media focus on forensic science has been mainly through:

i. News: Controversial cases have always occupied news headlines all over the world such as: the assassination of John F. Kennedy (1963), Lindy Chamberlain's case (1980s), O.J. Simpson's case (1994), and many others (Evans, 2003). Such cases have pushed forensic science to become a matter of public interest (Duquesne University, 2000).

ii. Television dramas: Forensics had not been 'popular or popularised' until the "very popular" C.S.I show started broadcasting, followed by many related programs: *CSI: Miami*, *CSI: NY*, *NCIS*, and *Bones* (Houck, 2006:1). These TV shows have brought the recent glamorous advances in forensic science techniques to public attention and popularity. These programs are argued to have created an influence of unrealistic perceptions of forensic science in the public in relation to what a forensic practitioner can in reality do and the timeframe it takes to obtain results and answers (Robertson (media), 2010).

The exaggerated expectations of forensic science are referred to as the "CSI effect" or "CSI Syndrome" (Lovgren 2004, Rincon 2005). The "CSI effect" is strongly argued to be reflected in the public's perceptions of what forensic science can or can't do, in students' high interest in forensic science courses and their high expectations of those courses, and in jurors' demand of unreasonable levels of forensic evidence through trials (Lovgren, 2004; Rincon, 2005; Houck, 2006).

iii. Documentaries: Forensics has been the topic of many documentaries and

[15] SEMTA: Science, Engineering, Manufacturing Technologies Alliance

reality-based shows in channels such as the Learning Channel and Discovery Channel (Smallwood, 2002).

1.6- Public Interest Consequences

Forensic science has enjoyed popularity and prominence as a result of the increased media and public attention (Houck, 2006; Mennell, 2006; Smallwood, 2002). This popularity and prominence prompted the development of specific courses of preparation in universities. For example, in the United Kingdom there are currently more than 500 courses with the word ‘forensic’ in the courses’ title distributed over the British universities (Daéid & Roux, 2010). A second example is Australia, where there are currently around 23 forensic science programs covering various specialisations and academic levels ((NIFS, Electronic[16]). A third example is the forensic program at West Virginia University in the U.S.A, where the program has grown from 4 students in year 1997 to more than 500 students in year 2006 (Houck, 2006). Such an expansion prompts an investigation into the nature of forensic science education: What is forensic science education? How is such education organised? Where does forensic science stand in academia?

1.7- What is forensic science education? A preliminary examination

In an attempt to investigate what forensic science education is, a typology of the published curricula of a number of the forensic science courses/programs offered worldwide was conducted. Published curricula of higher education courses generally incorporate details in regard to curriculum organisation, disciplines involved, and pedagogies adopted. Therefore, the preliminary examination of the curricula of a number of forensic science courses may be expected to produce preliminary insights about the nature and current status of forensic science education.

The preliminary examination considered 16 forensic science courses offered by institutes in various regions of the world. The names of the education providers

[16] http://www.nifs.com.au/F_S_A/FSA_frame.html?Courses.asp&1, Accessed: 02/08/10

offering these courses have been coded to keep program names anonymous. This procedure has been taken in compliance with the ethics requirements of the research. Coded names involved three letters followed by a 3 digit number. The three letters constitute the first three letters of the word 'typology'. The three digit numbers have been arbitrarily chosen (e.g. TYP104).

This preliminary examination focused on attributes relating to: 1) course title, 2) administering department, 3) academic level of offer through which the course is offered, 4) incorporated disciplines, 5) place and extent of practice within the organizing curriculum, and 6) career opportunities. The results of the typology are attached at Appendix B. Table-1b contains a sample of the typology results.

University/ Country	Sample Table of the Typology including 16 Universities Offering a Forensic Science Program
TYP-106 UK	**Level of Offer**: Undergraduate- **Course Title(s)**: Bachelor of forensic science
	Administering Department: School of biological sciences
	Syllabus: heavy biology component, with light forensic and chemistry components
	Place of Practice: 1 year of work placement between the 2nd and 3rd years in one of the forensic centres or law enforcement agencies.
	Career Opportunities: both public and private forensic laboratories
TYP-102 Australia	**Level of Offer**: Non-award TAFE degree- **Course Title(s)**: Certificate IV in forensic science
	Administering Department: Department of public safety and sciences
	Syllabus: forensic subjects of vocational nature (e.g. fingerprinting, physical evidence, crime scene processing, etc)
	Place of Practice: Syllabus is delivered by current forensic science practitioners
	Career Opportunities: Course intended to provide further training for personnel already employed as forensic practitioners, law enforcement officers, and security officers. The course also provides entry level employment opportunities in the forensic science industry
TYP-105 USA	**Level of Offer**: Undergraduate- **Course Title(s)**: Bachelor of science in forensic science
	Administering Department: Department of criminal justice
	Syllabus: Balance between science, forensic science, and law subjects
	Place of Practice: close association with state police department and state forensic medical laboratory; students are exposed to mock courtroom and real forensic laboratories
	Career Opportunities: Employment in criminal justice and forensic science fields

Table-1b

The preliminary data, revealed by this examination, strongly suggests that forensic science education is arbitrarily organised as the considered forensic science courses possessed no clear pattern(s) of:

a) The knowledge fields which should be incorporated (e.g. chemistry, biology, mathematics, physics, law, and/or forensic subjects),
b) The place and extent of practice, and
c) The identity of the field as indicated by: 1) the arbitrariness in the identity of the department administering forensic science courses (e.g. chemistry department, department of criminal justice, or school of bimolecular sciences); and 2) the non-consensus on the academic level at which forensic science education should start (non-award, undergraduate, and/or postgraduate).

These preliminary findings strongly support a further investigation on:

i. the way the forensic science knowledge base is created, organised, and taught;
ii. how this knowledge base reflects the nature of everyday practice and responds to industry needs and requirements; and
iii. the identity of forensic science and its relationship with forensic science education and everyday practice.

1.8- Forensic Science Education

Until the 1950s, forensic science lacked the existence of boards of review, boards of examination, formal education and training, organisations to run conferences and seminars, and regular forensic journals. Forensic science pedagogical frameworks and curricular activities were unpredictable and dissimilar to an extent that students had to search by themselves for a suitable course, should they wish to pursue a career in the forensic science field (Gerber & Saferstein, 1997).

Since the 2nd half of the 20th century, forensic science education has been promoted as ‘a co-curricular activity’ (Ehninger, 1952: 237) where many national and international organisations have been established as a result of this promotion. Some of these are:

- The American Academy of Forensic Sciences (AAFS): Established in 1948, AAFS started initially as an American academy, and has become an international organisation that represents United States, Canada, and 55 other countries. The AAFS objective is to promote professional forensic science education and practice through: 1) its recognized international scientific journal: *Journal of Forensic Sciences*, 2) newsletters, 3) seminars and workshops, 4) conferences, and 5) annual scientific meetings. Following a recommendation by the National Institute of Justice in U.S.A. for the need to set up national standards and an accreditation system for forensic science education programs, AAFS initiated an accreditation commission (FEPAC[17]) in 2002 to develop, maintain, and administer an accreditation program that recognises high quality tertiary forensic science programs (undergraduate & postgraduate) (AAFS, Electronic[18]). To be eligible for accreditation a forensic science program must: 1) be offered by an accredited educational provider, 2) offer at least a bachelor's degree in forensic science or in a natural science with forensic science concentration, 3) have graduated at least two classes prior to applying for accreditation and 4) have met the standards set out by the commission (FEPAC, 2003; 2009). However, the FEPAC has not yet been recognised as an accrediting organisation by the American Federal Board of Education (U.S. Department of Education, 2007) or by any federal agency (Hurley, 2007). This makes this accreditation process neither an obligation prior to establishing a forensic science program within a college or university, nor a requirement for admission to a forensic science career.

- National Institute of Forensic Science (NIFS): Established in 1991 in Australia, the core functions of NIFS are to sponsor and support research and training in forensic science and assist with the coordination and development of forensic science services. NIFS is concerned with raising the 'profile' of forensic science; therefore, it conducts quality assurance programs as part of the training it provides (NIFS,

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[17] FEPAC: Forensic Science Education Programs Accreditation Commission.

[18] http://www.aafs.org/default.asp?section_id=aafs&page_id=about_us, Accessed: 08/03/07.

2005).

Forensic science has proved itself to be a prominent area of science within the last 10 years (Mennell, 2006) enjoying a ‘huge increase in public interest’ (NIFS, 2006:7). As a result of the field’s prominence and popularity (Mennell, 2006), the number of education providers offering forensic science courses and the number of students enrolling in these courses have exponentially increased (Engber, 2005; NIFS, 2006).

Despite all its prominence and popularity, forensic science has not possessed a uniform curriculum or a consensus of what the educational requirements should be in specialised forensic science subjects (Jonakait, 1991). Moreover, despite the many strong forensic science courses offered worldwide, there are some arguments that forensic science education suffers from some weak and loosely organised courses (NIFS, 2006). The increase in the number of students studying forensic science comes in an era of decline in the number of students enrolling in higher education science courses (Mennell, 2006). These science courses are often chemistry courses in origin and have been threatened with closure as a result of this decline (NIFS, 2006). Some coordinators of science courses- chemistry in particular- have taken advantage of the recent flow in public interest towards forensic science (SEMTA, 2004). These coordinators have incorporated ‘greater or lesser amount of forensic content-sometimes by name only-’ in their curricula, in order to add or associate the adjective ‘forensic’ with the title of the offered courses; hence, the courses become more attractive and enrol more students (NIFS, 2006:10).

The weak foundation of many forensic techniques (Risinger & Saks, 2003) demand that more research be undertaken on forensic science and forensic science education. Burnett, Brand & Meister (2001) argue that little research has been undertaken and published on forensic science education. On the same issue, Dr Barry Fookes (2003), Head of the Forensic Science Program in University of Central Florida, argues that “I have surfed the web over the last five years looking at other programs and new courses world wide-of the many too many are criminal justice programs with a trace of what is termed here criminalistics…”. For more than thirty years, there has been ‘limited academic study in the area of forensic sciences' *versus* a steady growing 'demand for certificate and graduate education in the forensic sciences' (Duquesne University, 2000:1).

The random expansion in forensic science education worldwide, in addition to, the inconsistency and lack of clarity in the huge range of forensic science courses on offer have led to inconsistencies in skills and competencies acquired by the graduates seeking employment in the field, and hence to criticisms by potential employers (Lewis, Brightman, & Roux, 2005). Moreover, forensic science education departments lack formal arrangement with employers to discuss course content. Instead 'what exists is a series of ad hoc arrangements' which occur on an individual basis between employers and universities through which 'employers liaise with universities about particular courses' (SEMTA, 2004:88).

1.9- Forensic Science Knowledge

Forensic science is a very broad field. It applies physical, biological, medical, behavioural sciences and various technologies into matters relating to law (Gaensslen, 2003). This is supported by the argument that any science, scientific application, piece of knowledge, or craft may be invited into the judicial arena to solve a criminal or civil case (Inman & Rudin, 1997). This research has limited the working definition of forensic science to "that profession and scientific discipline directed to the recognition, identification, individualisation and evaluation of physical evidence by application of the natural sciences to law-science matters" (Nickell & Fischer 1999:2). Hence the knowledge base incorporated in forensic science- subsequent to the limitations set by the working definition- mainly comprises chemistry, biology, maths, physics, and knowledge about uniquely forensic forms of inquiry such as fingerprinting, firearms, tool mark examination, etc.

The forensic science knowledge base is based on:

i. a foundation of the basic scientific principles of physics, chemistry, and biology which underpins most of the techniques and methods used (Rudin & Inman, 2001); and

ii. a foundation of explicit ‘forensic principles’ which explains the way evidence is created, identified, and individualised (Horswell, 2004; Broeders, 2006).

The way forensic science knowledge is created, organised and transmitted is complex. This is supported by Barclay (2003) who argues that forensic science should be perceived in terms of its role in investigations and the outputs displayed as a result, rather than by trying to define forensic science in terms of its epistemology, as its epistemological definition is too complex.

1.10- Forensic Science Practice

Until the 1950s, the majority of forensic practice was performed by chemists and medical practitioners on an ‘ad hoc’ or ‘extracurricular basis’ as a result of the absence of formal education (Gerber & Saferstein, 1997). However, since forensic educators have echoed the educational value of forensic science (Allen, Berkowitz, Hunt & Louden, 1999; Gernant, 1991), there has been emphasis on the importance that students, within forensic science courses, learn the practices of a discipline and undertake the discovery of knowledge through experimental work (Burnett, Brand & Meister, 2001). The ways forensic practitioners perceive knowledge in their investigations derive from the broad disciplines of knowledge that underpin forensic science (Barclay, 2003). Forensic science curriculum has changed to explore practical experience and law in addition to core knowledge as the contents of forensic science courses have proven to be influenced by both the demands of law and the nature of practice (Abeyasinghe, 2002).

Forensic science practice nowadays is more organised than before. However, there is still no consensus on the educational pathways that need to be followed to pursue a forensic science career. Approaching a forensic science position from a course of study perspective, Rowh (2000) argues that a traditional 4-year science program (chemistry, biochemistry, biology, or a related field) is the minimum requirement for a forensic science career. Smallwood (2002:3) quotes Carla Noziglia, a retired forensic laboratory director, that "there's still a lot of controversy over hiring someone with a chemistry degree or a bachelor's in forensic science". According to the FBI Quality Assurance Standards for Forensic DNA Testing Laboratories, "…the technical manager or leader of a DNA section or laboratory shall have at minimum a Master's degree in biology, chemistry or a forensic science-related area" (University of California Davis, Electronic[19]).

From the legal perspective, Sides (2003) asserts that there is no consensus between members of the Australian Supreme Court on whether competence and expertise in forensic science practice can be achieved by either practical experience or field of study (Clarke v Ryan, 1960: 491-2, 498-99) or that expertise should be gained through a course of study (Clarke v Ryan, 1960:591-2). The American Federal Rules of Evidence – specifically Rule 702- admit scientific testimony from experts that are either qualified by education or skilled by training and experience (Jones, 2007). Hence, scientific tertiary education is not a prerequisite to practice forensic science. However, some scholars argue that even fingerprinting identification experts should have a sound scientific background. This is because fingerprinting identification became so readily accepted and used worldwide mainly because their effectiveness had been demonstrated by Galton, a foremost anthropologist and statistician in the 19th century, who enjoyed an enormous stature in the scientific world (Thornton, 2000). There have also been some recent discussions within the forensic community on the necessity of re-considering the appropriate level of qualification needed as a prerequisite for entry into forensic science practice in both field and laboratory, due to three main reasons: 1) 'the fact that much of science is now moving from the laboratory to the field', 2) the increased duty of care incumbent upon supervisors regarding the use of chemicals and abiding with occupational health and safety requirements (NIFS, 2006:13), and 3) the recurrence of "abuse cases" where forensic evidence presented to courts is based on an unreliable scientific premise- 'junk

[19] http://forensicscience.ucdavis.edu/, Accessed: 02/04/09.

science’- because law enforcement personnel lacked a proper scientific background (Giannelli, 2006:312).

1.11- Forensic Science Identity

Forensic science has drawn media and public attention (Smallwood, 2002; Kobus & Liddy, 2008), a fascination with science unseen since the Apollo Space Program following human advancement in astronomy (Houck, 2006). Despite the prominence and high stature forensic science has gained within the general public and the consequent expansion it has achieved within higher education institutions, forensic science ‘has not enjoyed a similar rise in stature within the academic community’ (Jonakait, 1991:6). Garrison (1991:1) asserts that forensic science identity is complex because it is the ‘product of an uneasy and unholy mating of science, the objective seeker of truth and knowledge, and forensics, the argumentative persuader of courtroom advocacy’. Similarly Inman and Rudin (2000) argue that the identity of forensic science remains complex and can be partly approached from society’s perceptions.

Forensic science disciplinary uncertainty is reflected in the argument that forensic science hasn’t yet emerged as a ‘stand-alone’ discipline and often is delivered merely as a technical derivative of existing fields (Smallwood, 2002). Forensic science programs are often housed in a chemistry department and treated as a chemistry derivative (Smallwood, 2002) although it may include other sciences and applications that can be invited to solve cases pertaining to law (Inman & Rudin, 1997). On top of disciplinary uncertainty, forensic science identity suffers dilemmas, controversy, and a great deal of uncertainty with respect to the nature of the ‘science’ in forensic science:

a) Whether or not forensic science is a ‘science’; Whether or not this ‘science’ is unique and enjoys valid and reliable techniques (Giannelli, 2003, 2006; Henderson, 2004; Risinger & Saks, 2003).

b) Whether or not the identity of science in forensics changes between criminal and civil cases (Kiely, 2006).

These dilemmas add up to forensic science complexity and uncertainty and urge more research and scrutiny to identify the nature and identity of forensic science.

1.12- Problem Identification

As addressed in section 1.3 (history of forensic science education) the majority of publications, research and curricular activities of forensic science were conducted starting the 1950s. Since the 2nd half of the 20th century, the forensic science field has experienced the emergence of boards of review and examination, formal education and training, conferences and seminars, and regular forensic journals and publications (Gerber & Saferstein, 1997). Therefore, forensic science is a relatively new and developing field in terms of its education, practice and stature.

Forensic science definition and identity are complex (Inman & Rudin, 2001, Barclay 2003) because ‘any profession, discipline, craft, or art may potentially be invited into the judicial arena, simply, by adding the adjective ‘forensic’ to it (Inman & Rudin, 1997:3). On the same issue, Taylor and Meux (1997) argue that forensic practitioners find applying knowledge, expertise and research findings into daily practice complicated and problematic due to the constantly changing circumstances surrounding forensic science practice in real life. Therefore, complexity and uncertainty issues are experienced at the epistemological level of forensic science, in the nature of the actual practice, and within a wide grasp of images, profiles, impressions expectations, and perceptions that attempt to shape the identity of the field.

Forensic science education has been marked by controversy about the nature of the knowledge fields that may be included in a course of study to relate to forensic science practice and reflect forensic science identity. Forensic science pedagogy has been marked by controversy on where to start course delivery (undergraduate, postgraduate, etc); on how, if at all, to frame a forensic science major; whether to frame it within a traditional science curriculum, a specialised stand-alone forensic science course, or an interdisciplinary model of pure sciences and forensic sciences.

The problem arises in how a forensic science curriculum might respond to its inherent epistemological complexity and uncertainty. Furthermore, the problem ramifies when it comes to developing a forensic science course/ program in academia which: a) comprises the forensic science knowledge base, b) reflects the nature of forensic science practices, c) possesses the identity and image of the forensic science field, and d) responds to industry needs and requirements.

1.13- Research Aims & Questions

The aim of this research is to approach the question of how do the curriculum and pedagogy of forensic science courses reflect the nature of forensic science by recognizing its complexity and disciplinary uncertainty as a starting point. Its elusive quality notwithstanding, forensic science has emerged in the last 100 years as a prominent professional domain with high social status and increasing political significance. The research, therefore intends to locate itself in the practices of forensic science and of forensic scientists and forensic science educators. The aim of the research is to approach forensic science epistemological complexity through generating an understanding of the knowledge base of forensic science education from a consideration of both current forensic science courses and the perceptions and conceptualisations held by forensic science educators, practitioners, and members of associated professions about: a) The professional practices of forensic science; b) The ways in which knowledge and understanding about forensic science are created organised and transmitted, and c) The identity of the forensic science field; that is the extent to which forensic science is a distinct applied knowledge field or merely a technical derivative of existing fields.

In order to meet the aims and objectives of this research, the following major research question and associated supporting research questions have been established:

Major Research Question:

"How do the Curriculum and Pedagogy of Forensic Science Courses Reflect the Practice, Knowledge and Identity of the Forensic Science Field?"

Supporting Research Questions:

1- How do published curriculum documents of a selected set of current forensic science courses portray the nature of the practice, knowledge and identity of the forensic science field?

2- What are the perceptions of forensic science practice, knowledge and identity held by a selected group of Australian forensic practitioners, educators and members of profession?

3- What are the perceptions of current forensic science courses held by a selected group of Australian forensic practitioners, educators and members of profession?

4- In what ways do those perceptions indicate the complexity, if any, of forensic science and forensic science education?

5- How can a comparison of the document analysis of current forensic science courses with the analysis of interviewees' perceptions provide a curriculum and pedagogical framework for forensic science education?

1.14- Research Stance

The researcher in this study conducted both the data collection and analysis. Appropriate checks and balances were incorporated in the design of the study to limit the influence of researcher bias upon the process and results. The researcher has previous experience and a sufficient knowledge base of forensic science and the various domains incorporated within. This experience and knowledge base derives from the researcher's:

a. Educational background: The researcher holds a BSc (Hon) in chemistry where the honours research was conducted in the area of forensic chemistry;

b. Research experience: The researcher participated in a research in the area of forensic biology (DNA profiling); and

c. Academic participation: The researcher participated in a number of forensic science seminars, workshops, and international symposia (e.g. 16th and 19th International Symposia on Forensic Science in Australia and 4th Mediterranean Academy of Forensic Sciences Meeting in Turkey).

In relation to this prior experience and knowledge base, the researcher adopted the position of Burns (1994) that this background provides an invaluable point of reference for the issues being explored. This prior knowledge has helped the researcher in designing and setting the research methodology. The effect of researcher bias on the results is contained by maintaining an open mind throughout the conduct of the research, following accepted procedures, and subjecting the outcomes to critique. In addition, the adopted methodology carefully compared and contrasted the various data sources. The uses of quantitative and qualitative methods have given the researcher multiple data triangulations. All this have reduced the potential researcher bias.

1.15- Research Design

The research design and the research methodology of this study were chosen to achieve the research aims and to answer/ or attempt to answer the research questions generated (major & supporting research questions). The aim of the research is to engage the epistemological complexity of forensic science in order to generate an understanding of the knowledge base of forensic science education. Hence, the research methodology is comprised of two phases: a document analysis and semi-structured interviews.

a) Document Analysis

Preliminary results obtained from the typology of 16 forensic science courses strongly supported undertaking a thorough detailed document analysis of current forensic science courses. Hence, the research conducted a comprehensive document analysis which considered the published curricula of 190 forensic science courses offered by various higher education institutions worldwide. Document analysis generated an understanding of the current status of forensic science education, a field where little is known or published. It also generated conceptual attributes about the knowledge base incorporated within forensic science, the nature of the practice of forensic science, and the identity of forensic science: the extent to which forensic science is a distinct applied field of knowledge or merely a technical derivative of existing fields.

b) Semi-Structured Interviewing

Semi-structured interviews comprised the second phase of the research methodology. Interviews were conducted with forensic science educators, practitioners and members of professions associated with forensic science. These interviews examined the interviewees' perceptions and conceptualisations about the nature of forensic science practice, contributing knowledge base, and identity. These examinations generated insights about: 1) the nature of forensic knowledge and the curricular and pedagogical approaches which may respond to such a nature, 2) the nature of forensic science practice and the features of such practice, and 3) the identity of forensic science as both a field of practice and study. The interviews were conducted in Australia with 14 Australian participants comprising: 4 forensic science educators, 6 forensic science practitioners and 4 members of professions associated with forensic science. Data recorded from semi-structured interviews were transcribed, coded, and analysed.

Finally, the conceptual attributes generated by the document analysis were cross-examined and compared with those generated by the semi-structured interviews. Such cross-examination and comparison identified issues and themes relating to forensic science education in terms of the way the curriculum and pedagogy of a forensic science course may be organised to respond to the nature of forensic science knowledge, practice and identity.

1.16- Appropriateness of the Methodological Approach

This research adopted a two-phase methodological approach: document analysis and semi-structured interviews. Document analysis was conducted on the published curricula of 190 forensic courses/programs offered worldwide. Semi-structured interviews were conducted with 14 personnel amongst three groups: forensic science educators, forensic science practitioners, and members of professions associated with forensic science.

Forensic science education has expanded dramatically since the last two decades. The typology which was conducted on 16 forensic science courses/programs earlier in this chapter- section 1.7- generated preliminary implications about the arbitrariness in organising forensic science courses. The typology reflected a certain extent of uncertainty in the nature of forensic science knowledge, practice, and identity and suggested the need for further investigation.

This research aimed to investigate the curricular and epistemological complexity of forensic science by conducting a systematic methodology. This methodology started with an investigation about the current status of forensic science education in academia as very little is known or published about such status. This investigation was conducted through the first phase of the research methodology: document analysis. Document analysis provided a holistic image of the current status of forensic science education. It also provided imperative insights about the nature of forensic science knowledge, practice, and identity through identifying: the way higher education institutes organise forensic science education, transmit forensic science knowledge, and liaise with the forensic science industry.

Despite its importance, document analysis generated implications and insights based on static data published by courses coordinators. This data may not necessarily reflect opinions about 'what is best to be done', but rather the opinions of 'how things need to be done' as seen from the lens of a forensic science course coordinator. Hence, there was a need for an additional 'active' methodological component which can reflect the opinions and perceptions of stakeholders of the field. Therefore, semi-structured interviews comprised the second stage of the research methodology. Interviewees had been selected in a manner which represents the different stakeholders of forensic science: forensic science educators, practitioners, and members of associated professions. These interviews aimed to generate deeper and more practical insights into forensic science education based on the perceptions and informed opinions held by personnel directly involved with forensic science at universities, crime scenes, laboratories, and/or courts. Themes generated from both document analysis and semi-structured interviews were cross-examined and compared. Such cross-examination and comparison provided a holistic approach for mapping forensic science knowledge, practice, and identity to better understand, organise, and develop the education of this emerging academic field.

1.17- Limitations of the Study

The scope of the study is limited by the working definition of forensic science, which is confined to the application of physical sciences, biological sciences, and other explicitly forensic forms of inquiry and techniques (e.g. crime scene processing, fingerprinting, etc) to matters pertaining to both criminal and civil law. This is because it is nearly impossible to cover all or even most of the disciplines that are directly related to, associated with, or invited to the forensic science arena (e.g. forensic anthropology, odontology, entomology, psychiatry, computing, accounting, etc). The restriction of the working definition has simplified the conduct of this research and made it possible. However, it has eliminated the scope of insights which might have been attained by those other forensic science disciplines, specialisations, and associated fields.

A second limitation results from the fact that whilst document analysis is representative of various forensic science courses/programs offered worldwide, semi-structured interviews were conducted explicitly with Australian personnel about their perceptions, experiences, and informed opinions. This is because interviewing personnel from various countries demands resources beyond the research's funding and timetable. However, many of the participants who were interviewed had participated in a number of overseas forensic missions, held an overseas forensic science position for a period of time, and/or participated in a number of the international forensic science symposia. Those overseas experiences and/or participations add an international dimension to the research.

1.18- Significance of the Study

Little research on forensic science education has been undertaken and published (Burnet et al., 2001; Fookes, 2003). Therefore, the main contribution of this research will be its mapping of the nature of knowledge and practice in a politically and legally significant professional field. The outcome of this study will have implications for forensic science education. The research will also add to knowledge of emerging professions of multi-, inter-, or trans-disciplinary nature and provide knowledge about the developing state of curriculum inquiry in higher education, which will have the potential to support further curriculum innovation.

This research is doubly significant. Primarily, the research is significant because it will provide a window into how possible forensic science courses could be structured, leading to the graduation of more knowledgeable and effective forensic scientists. This will benefit the forensic science community and associated social groups who rely on forensic science practice such as the police and legal practitioners. Secondly, the research will help define emerging fields of practice, similar to forensic science in their disciplinary complexity, identity uncertainty, and place in higher education.

1.19- Thesis Structure

This chapter has presented the central research question and specific aims which guide the exploration of forensic science education in terms of its determining factors: knowledge, practice, and identity. Definitions, landscape, and historical background of forensic science were presented in order to contextualise the study. A brief overview of the research methodology was also presented, situating the research and orienting the reader.

Chapter Two emphasises the two main bodies of literature which inform the study. The first body of literature mainly examines literature concerning: a) tertiary education and curricula adopted at tertiary institutes, b) the theory of science and science education, c) medical education as a comparative case study similar to forensic science education, d) the discourse on curricular integration, e) the discourse on the different pedagogies, f) decisions about curricular and pedagogical approaches, and g) the role of tertiary education in emphasising generic skills. The first body of literature explores the notions of three leading scholars in the areas of: curriculum (William Pinar), science education (Thomas Kuhn), and sociology of education (Basil Bernstein). The second body of literature explores the three determining factors of forensic science education: knowledge, practice, and identity. The notions of the three scholars, examined in the first body of literature, will be explored through the lenses of the determining factors of forensic science education in order to create an informative landscape for the further analyses and discussions which will take place following data collection.

Chapter Three outlines the research methodology chosen for this study. The rationale underpinning the details of the research design is addressed. The first phase of the research methodology: document analysis is addressed. Procedures governing the selection of the forensic science courses/programs, data coding, and data analysis are explained. The second phase of the research methodology (semi-structured interviews) is then addressed. Procedures governing the selection of participants, interview process, data coding, and data analysis are explained. The findings resulting from the document analysis are presented in chapter four. The findings resulting from the semi-structured interviews are presented in Chapters Five, Six, and Seven.

Chapter Four presents the criteria adopted to select the final 15 courses/programs from a starting list of 190 courses/programs. Statistical significance and analysis associated with the selection criteria are detailed. Data collected from the final selected courses/programs are coded in reference to three conceptual attributes: knowledge, practice, and identity. Data analysis within each attribute is undertaken. Cross-comparison between the three attributes is conducted to generate themes referring to the current status of forensic science and forensic science education.

Chapter Five outlines the qualitative data collected from participants in the semi-structured interviews relating to their perceptions of forensic science knowledge. These perceptions are analysed to identify 5 categories of description representing major conceptions of forensic science knowledge. Inter-categorical analysis then takes place to summarise the overall position of the three groups of participants from each identified category of description. Cross-categorical synthesis is finally adopted to generate themes relating to forensic science knowledge.

Chapter Six presents the qualitative data collected from participants relating to their perceptions of forensic science practice. This chapter follows a similar approach to Chapter Five in identifying 4 categories of description representing major conceptions of forensic science practice. Inter-categorical analysis then takes place to summarise the overall position of the three groups of participants from each identified category of description. Cross-categorical synthesis is finally adopted to generate themes relating to forensic science practice.

Chapter Seven outlines the qualitative data collected from participants relating to their perceptions of forensic science identity. This chapter follows a similar approach to Chapters Five and Six in identifying 4 categories of description representing major conceptions of forensic science identity. Inter-categorical analysis then takes place to summarise the overall position of the three groups of participants from each identified category of description. Cross-categorical synthesis is finally adopted to generate themes relating to forensic science identity.

Chapter Eight maps the findings of the document analysis (Chapter Four) with that of the semi-structured interviews (Chapters Five, Six, and Seven) in order to generate a re-contextualised and re-conceptualised understanding of the nature of forensic science knowledge, practice, and identity. This chapter identifies ontological and epistemological complexities which will be challenging for any forensic science course.

Chapter Nine proposes the teaching and learning settings consistent with the identified nature of forensic science knowledge, practice, and identity as reported in Chapter Eight. This chapter also summarises the complexities which face forensic science education. Then the chapter reports the features of a forensic science course which reflect the nature of forensic science and acknowledge the complexities of the field. Chapter Nine then initiates a discussion about what constitute authentic versus inauthentic investment in forensic science education. This chapter concludes by reflecting on the limitations of the research findings and prospective opportunities for future research in the area of forensic science education.

1.20- Chapter Summary

Forensic science is a very important field to police, judicial systems, governments and the general public. Forensic science is now one of the vital factors in retaining societies' balance and security following a murder or a serious offence. Publicity of forensic science has extended from media and general public to academia, where the numbers of the offered forensic science courses and the numbers of the students enrolling in such courses have dramatically increased. The research adopted a preliminary investigation into the current status of forensic science education through a typology of the published curricula of 16 forensic science courses. The research noted the arbitrariness and randomness of forensic science education as implied by the conducted typology. The typology exposed a degree of uncertainty in the nature of forensic science knowledge, practice, and identity and has been the starting point for further investigation.

The research has set questions which have guided the investigation into the features of forensic science education. The research has adopted a methodology which attempts to solve the research problem and answer the research questions.

The outcome of the research will be insights into how possible forensic science education could be organised and how possible forensic science courses could be structured to lead to the graduation of more knowledgeable and competent forensic practitioners. This would benefit forensic science educators, forensic science practitioners and members of associated professions who rely on forensic science practice. Implications generated by the research will also help define emerging fields of practice, similar to forensic science in their disciplinary complexity, identity uncertainty, and stature in higher education.

Chapter Two will address the two main bodies of literature which constitutes the literature review of this research. These two bodies of literature integrate to inform the analysis of the collected and coded data at later stages in the thesis.

Chapter 2: Literature Review

2.1- Introduction

The literature review which will inform the research analyses and discussions is subdivided into two main bodies: a) The education body of literature and b) the forensic science education body of literature. These two bodies of literature will interconnect to form the landscape upon which the research findings and recommendations will be generated.

The education body of literature emphasises the beliefs and perceptions of a number of scholars. These beliefs and perceptions will inform the research discussions about the nature of forensic science education and the curricular and pedagogical approach(s) which reflect such a nature. William Pinar, Thomas Kuhn, and Basil Bernstein are the main scholars informing this research. The notions of these scholars which are of main concern to this research are as follows:

- William Pinar's conception of the curriculum as being a complex conversation between the various stakeholders who are directly/indirectly involved or concerned in the organisation, setting, and delivery of such a curriculum,

- Thomas Kuhn's notion of science and scientific theory, particularly in terms of associating normal scientific periods to reigning paradigms, relating revolutionary scientific periods to paradigm shifts, and identifying common solutions to common problems in a scientific field as being exemplars of such field, and

- Basil Bernstein's notion of the sociology of education, particularly his notion of power and control of the various social groups concerned with the education of a particular field in shaping the curriculum and pedagogy of such a field.

The forensic science education body of literature comprises literature about forensic science education. This body of literature examines the determining factors in forensic education: knowledge, practice, and identity. Such an examination focuses on:

- the guiding principles of forensic science knowledge,
- the premise, categories, and specialisation of forensic science practice
- the identity of forensic science as perceived from different lenses and perspectives.

Literature about forensic science knowledge, practice, and identity will be used to inform the research discussions on how best forensic science programs/courses can be structured in order to reflect and relate to: a) the professional practices of forensic science; b) the ways in which knowledge and understanding about forensic science are created organised and transmitted, and c) the identity of forensic science.

This chapter starts with the education body of literature. Then it proceeds to literature about forensic science education. Finally a concluding section relates the two bodies of literature. This last section shows how the two bodies of literature relate to one another in informing research analyses and discussions.

2.2- The Education body of Literature

The education body of literature comprises seven subsections. The first subsection addresses the aims, objectives, and hierarchy of higher education. It then explores literature pertaining to conceptions of and notions about curricula in higher education; how such curricula emphasise general knowledge, specific subject knowledge, and a wide range of essential competencies; how such curricula need to respond to communities' needs and market demands; and how the basis, structure and content of such curricula have been and will always be changing in response to the changing nature of human knowledge. In this subsection, William Pinar's perceptions of the curriculum are explored.

The second subsection introduces the definition and theory of science and emphasises what is scientific and non-scientific amongst human activities. Objectives and concerns of science education are then addressed. Different forms of knowledge, including scientific knowledge, and the different ways such knowledge can be acquired are detailed. Deficiencies in science education are examined. Calls for change in science education to respond to the new requirements and demands of the third millennium are also emphasised. Thomas Kuhn's notion of science and scientific change (shift) is explored in this subsection.

The third subsection introduces medical education as a case study in comparison with forensic science education. This comparative reading has been based on scholars' arguments about the resemblance between medicine and forensic science as both are 'pluri-disciplinary' fields of knowledge. This subsection details the various integrated curricular models and pedagogies which have been adopted or recommended in medical education to recognise the knowledge, practice, and identity aspects of medicine. The models of curricular integration and pedagogies which have been argued to be useful in medical education may be of similar usefulness in forensic science education. Therefore, literature about curricular integration and pedagogical approaches need to be introduced to create a reference for the data analysis and proposition of findings.

The fourth subsection introduces the literature pertaining to curricular integration: the reasons for integration and the various forms under which integration may exist. This section starts with Bernstein's philosophy about the existence of two broad categories of curricula: collection-type curriculum and integrated-type curriculum. Subsequent to the introduction of Bernstein's two broad curricular categories, the specific forms of curricular approaches which exist between these two broad categories are addressed: discipline-based, multidisciplinary, interdisciplinary, and transdisciplinary curriculum.

The fifth subsection introduces the various pedagogies which may be adopted to transmit knowledge. The teaching and learning approaches emphasised are: conventional lecture-based learning, problem-based learning, and practice-based learning. Advantages and disadvantages of each pedagogy are addressed.

The sixth subsection examines the decision-making about curriculum classification (integration) and content framing (pedagogical approach) from Bernstein's perspective. This subsection emphasises Bernstein's notions of power and control expressed by the social groups concerned with a specific field/discipline and how such power and control contribute in the curricular and pedagogical decisions related to this specific field/discipline.

The seventh subsection examines the role of higher education in promoting discipline specific skills, graduate attributes, and generic skills.

2.2.1-Tertiary Education and Curricula

In this section, the research addresses the aims, objectives, and hierarchy of higher education. Then, the research explores the notion of curriculum, particularly from a higher education perspective.

2.2.1.1-Higher Education

Higher education is post-secondary education which mainly aims to 'cultivate the attitudes and the traits of the students' character' (Ray, 1990:505) through increasing students': 1) respect for truth, worth and rights of others, 2) appreciation of own worth, 3) acknowledgement of ignorance and tininess within the vast universe, 4) love of wisdom and desire to learn, 5) philosophical viewpoint about humanity's position and destination in the world and desire for an inquiring mind in order to discover higher perspectives of life (Williams, 1968:29-30).

To meet the new requirements of the third millennium, the objectives of higher education need to change in a manner which: provide 'well-organised and flexible accessible domain-specific knowledge base', adopt 'heuristic methods', adopt 'metacognition', and involve 'affective components such as beliefs, attitudes, and emotions relating to a subject-matter field' (Erik de Corte: 1996: 113-115).

Higher education fulfils its aims not only by 'transmitting cognitive information', but also by 'providing each student with opportunities, that broaden and deepen a developing philosophy of life' (Carr, 1970:76), where entry into a profession constitutes one of those opportunities (Vitkauskaite, 2001).

In higher education, universities are the sites upon/through which knowledge is transmitted, produced, and applied (Lawrence & Despres, 2004). Universities are 'knowledge organisations' responsible for a) teaching, b) facilitating and supervising research, and c) serving local communities (Bowden & Marton, 1998). However, during the past decade, 'emphasis on transfer and acquisition of knowledge and skills in university programmes was extensively questioned' (Dall'Alba & Barnacle, 2007:680). A number of scholars argued that such epistemological emphasis requires reconceptualisation to address ontological considerations in higher education (Dall'Alba & Barnacle, 2007).

Epistemology is the questioning of knowledge, the assumptions upon which it is based, and therefore questioning what we "do know" and "can know" (Allison, 2000:13). Ontology is concerned with 'the nature of reality', where it focuses on the lenses 'through which we see and experience the world' (Allison & Pomeroy, 2000:92). Knowing and being are interdependent (Thomson, 2001). Hence, when understandings about the being and existence of certain fields of knowledge change, epistemological decisions regarding such fields transform as well (Thomson, 2001). Based on Thomson's argument, Dall'Alba and Barnacle stress that teaching and learning in higher education needs to promote the integration of knowing, acting, and being (2007).

The Australian qualification framework (AQF) details the hierarchy of education qualifications. This hierarchy starts at either secondary schools or TAFE and progresses in the form of vocational education qualifications, higher education qualifications, and/or through common- overlapping- qualifications between vocational and higher education (AQF, Electronic[20]) as shown in Figure-2a.

One of the recent developments characterising higher education is the accommodation of both work-based qualifications and academic qualifications within a single system to allow for maximum flexibility in career planning and continuous learning (AQF, Electronic[21]).

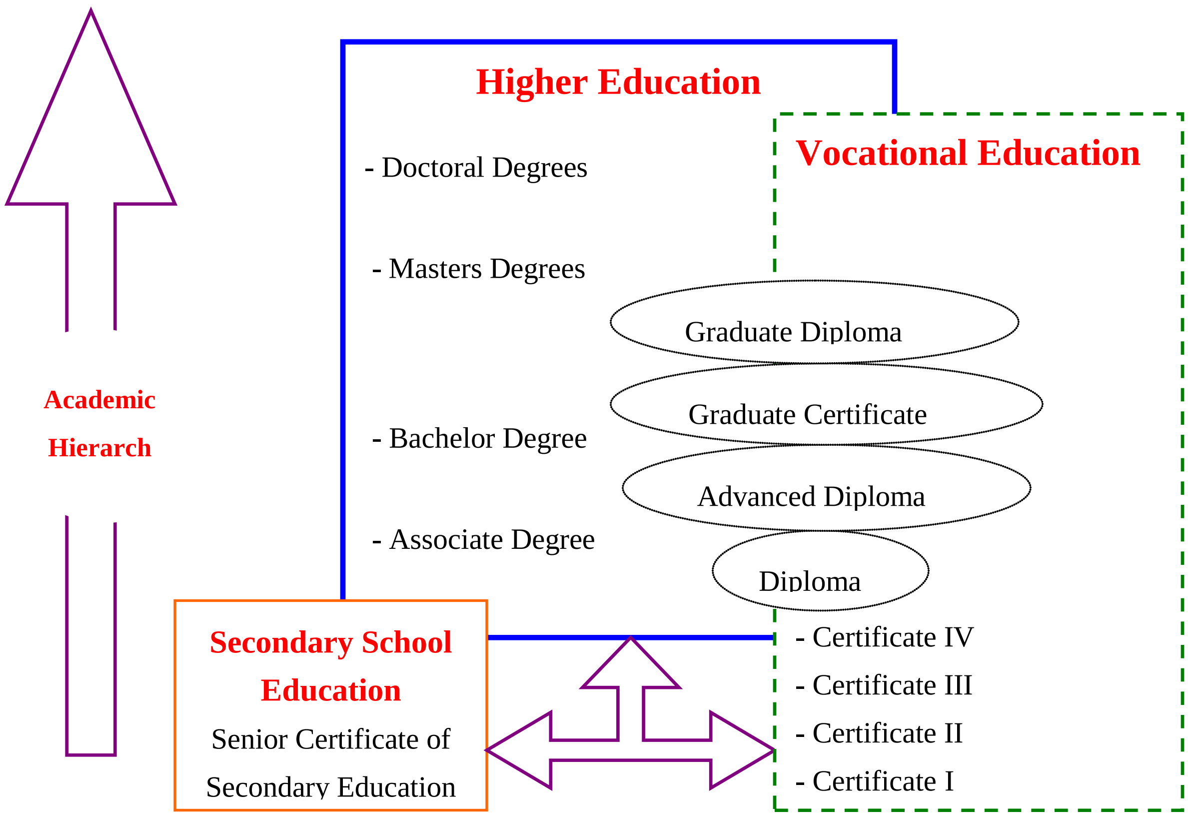

Figure 2a- Modified and expanded from Australian Qualifications Framework (AQF)

A European workshop, concerned with higher education in the 21st century, reported two major arguments: the first argument conceived higher education as an 'extension of universal schooling', while the second argument conceived higher education as a 'diversified system' which retains 'old universities' as centres of learning and research,

[20] http://www.aqf.edu.au/aqfqual.htm, Accessed: 12/11/07.

[21] http://www.aqf.edu.au/aboutaqf.htm, Accessed: 12/11/07.

whilst creating ‘new universities’ and colleges which focus on various market innovations and developments to meet employment requirement (Burgen, 1996:211).

Universities are, with their academic facilities and industrial links, an essential component of the modern economy. They form an investment which might or might not be profitable depending on: 1) how prepared their students are for employment; 2) how many of their graduates are employed and 3) how well their alumni are performing as employees or practitioners within various industries and specialisations (Cullingford, 2004). However, some modern universities- ‘new universities’- are criticized by some scholars as being only devoted to responding to government’s wishes and fulfilling businesses’ obsession with income, whilst giving up their historic fundamental role as a ‘civilizing force’ and a source of moral development (Cullingford, 2004).

Knowledge is not confined to universities and other higher education institutions, for Allen Tough (1987) argues that adults are constantly learning even if their learning is never ‘recognized or assigned a value’ by academics. However, one of the major benefits of learning through universities is that universities give credentials to the various forms of knowledge they transmit so that their graduates enjoy academic, social, industrial, and financial stature (Smith, 2004). People with ‘untapped knowledge’ do possess developed capacities and competencies. However, their skills and competencies remain unrecognized because they have not had their knowledge assessed and recognized by an academic body or institution (Smith, 2004:30).

2.2.1.2- Curriculum in Tertiary Education

Curriculum is a contested field that has been approached by many scholars throughout the history of the education literature. The word ‘curriculum’ originates from Latin meaning ‘racecourse’ as for many students the school curriculum is a race full of obstacles and barriers which need to be overcome to be able to finish the race (Marsh, 2004). Since the 4th century B.C., curriculum as a term was used by Plato and Aristotle to describe the subjects taught during the classical period of Greek civilization (Marsh, 1986). Modern scholars have approached curriculum- as term and content- from various perspectives:

- Stenhouse (1975: 1-2) asserts that curriculum can be seen as an 'intention, plan or prescription, an idea of what one would like to happen in schools'. Curriculum can also be seen as the 'existing state of affairs in school, what does in fact happen'.
- Basil Bernstein (1977:80) defines curriculum as 'a principle or principles, whereby of all possible contents of time, some contents are given a special status and enter into an open or closed relation with each other'.
- Pratt (1980:4) argues that curriculum is 'an organised set of formal and/or training intentions… a blueprint for activities'.
- Marsh (1986: 8-9) emphasises that curriculum in its broadest meaning is about what to teach in schools and how this selected subject matter is to be taught. It is 'an interrelated set of plans and experiences that a student completes under the guidance of the school' (Marsh,1997:5)
- McKernan (1996:21) believes that 'curriculum is a practical and highly moral matter which views itself as a changeable process, capable of transforming human action and, indeed, culture'.
- Brady and Kennedy (2003:3) argue that curriculum is a 'private transaction' between teachers and students; however, this transaction operates within broader social, political, and economic contexts.
- Walker (2003) asserts that curriculum is a particular way of ordering contents – topics, themes, concepts, or works, to fulfil the purposes of teaching and learning.

One of the leading scholars in curriculum theory is William Pinar. Pinar defines curriculum theory as 'the interdisciplinary study of educational experience... a distinctive field of study, with a unique history, a complex present and an uncertain future' (2004:2). Curriculum is 'what the older generation chooses to tell the younger generation … [it] is intensely historical, political, racial, gendered, phenomenological, autobiographical, aesthetical, theological, and international' (1999:366).

Pinar argues that curriculum needs to be perceived as a multidimensional text in which the major currents of the culture are expressed, denied, distorted, or reconstituted in complex ways (1988b). He asserts that curriculum undertakes reproduction through a reconceptualisation process, where the curriculum accommodates an enlarged knowledge base and a reformulated centre able to cope with cross-disciplinary fields of knowledge, emerging from cross-bordering traditional sciences, and to reflect social notions and themes associated with such emerging fields (Pinar, 1988b). Pinar's notion of the curriculum as a process reconceptualisation gave rise to his subsequent notion about the curriculum as being a complex conversation (Pinar, 2004).

Curriculum ceases to be the materialistic notion of a number of text books or a highly structured syllabus required to be covered within a specified period of time (Pinar, 2004). It is now seen as a 'highly symbolic concept... a process... an action, a social practice, a private meaning and a public hope' (Pinar, Reynolds, Slattery & Taubman, 1995: 847-848). Such high level of abstraction contributes in the complexity of curricular discourse (Pinar, 2004).

Curriculum is a complex conversation between professors, teachers, students, management (school or university management), politicians, and other stakeholders (Pinar, 2004). It is a complicated discourse about "what to teach", "how to teach", and how to organise and advance academic disciplines at universities (Pinar, 2004). In such curricular conversation, 'generations struggle to define themselves and the world' (Pinar, 1999:366).

Pinar also refers to curriculum as a complicated conversation, when he approaches the topic of internationalisation of curriculum (Pinar, 2010). In such a context, curriculum complexity requires discourses not only across various stakeholders of the one society and culture, but also across national borders with all the historical, cultural, social, and political complications associated with such conversation (Pinar, 2010). Pinar's notion of the curriculum as a conversation seems able to situate forensic science education as a discourse between the diverse stakeholders and social groups involved with forensic science.

Agreeing with Pinar, Kelly asserts that curriculum decisions are complex because curriculum can be conceptualized from different perspectives reflecting the different ways people conceive human knowledge and the 'problematic nature' of such knowledge (Kelly, 1999:26). Hence, curriculum is strongly correlated with the specific environment, community, and people to whom it is addressed. In other words, what might be an effective and impressive curricular approach in one culture might be perceived as totally ineffective and unimpressive in another (Ogborn, 2005).

Curriculum 'remains one of the most important products that higher education institutions offer to their customers' (Barnett, Parry & Coate, 2001:435). The objective of a higher-education curriculum is to enable students to continue their intellectual and social education into early adulthood within an environment which meets students' transitional needs and provides them with an adequate exposure to practitioner skills and abilities (Fielding & Cavanagh, 1983).

The history of transformation of higher education curriculum shows a set of variables such as beliefs, values and society attitudes, whilst maintaining one constant theme: 'responsiveness of the curriculum to the constituency it serves' (Menges & Mathis, 1988:196).

Since the 1990s, changes in higher education have subsequently led to developments in curriculum structure and delivery. These changes urged for higher education curriculum to cater for more vocational activities, students' range of backgrounds, more flexibility in meeting students' choices, students' individual strengths, and independence in the way students learn (Smith, 2002).

First-year university courses are expected to cater for introductory and core subjects in order to create a match between university-level education and secondary school education on the one hand, and develop scope for problem-solving competencies and creativity on the other (Edwards, McGoldrick & Oliver, 2006). The design of final-year courses is expected to be a development of previous years combining some core subjects, students' choice of modules, and independent research project or academic investigation. Such design also needs to cater for both ‘creative’ students, those seeking postgraduate education, and students who could not cope with too much ‘autonomy’; i.e. those students who would seek job searching straight after graduation (Edwards et al. 2006).

Modern curriculum has been- and will continue to be- strongly influenced by economics and the world of work. The labour market’s size, demands, and challenges contribute in both shaping higher education structure and content, and governing its aims and objectives (Menges & Mathis, 1988).

2.2.2-Science Education

Before attempting to define science education, it is essential to explore a working definition of the term ‘science’ in an attempt to recognise its richness, complexity, and differentiation from other human activities.

2.2.2.1- Science: Definitions, Views, and Theories

Science and its applications have had an enduring presence in accounts of human history. However, there is a great deal of disagreement on the nature of science and what can be classified scientific and what cannot (Duschl, 1994; Lederman, 1992). The conventional notion of science is that it is ‘a way of thinking that involves a continuous and systematic interplay of rational thought and empirical observation’ (Graziano & Raulin, 1993:14).

Whilst there this no definitive view of what science is (Wellington & Ireson, 2008), nowadays science is perceived as being characterised by a ‘plurality of views’ (McComas, Almazroa & Clough, 1998: 512): science is empirical, durable, tentative, descriptive, creative, correlative, social, historical, and cultural (McComas & Olson, 1998). In this respect, Matthews (1997) argues that being scientific is not about being indoctrinated but rather being objective, open, and critical. Science is ‘primarily concerned with the development of human knowledge (subject matters and processes) that helps us to understand the real world as objectively as possible and to interact with this world as constructively as possible' (Halloun, 2006: 2). Science as an activity and thought is 'a human activity' that: 1) 'has a set of aims intrinsic to it'; 2) adopts 'various methods' to produce a result; 3) 'is guided by methodological rules'; and 4) is performed by personnel possessing a scientific attitude of objectivity, rationalism, openness, and critical inquiry (Nola & Irzik 2005: 202).

Rodger Bybee, Janet Powell and Leslie Trowbridge approached science as a body of knowledge, a continuous inquiry process, and a social (human) enterprise:

> *Science is a body of knowledge about the natural world, formed by a process of continuous inquiry, and encompassing the people engaged in the scientific enterprise. The type of knowledge, the processes of inquiry, and the individuals in science all contribute in various ways to form a unique system called science (2008:39).*

Science is an 'intellectual process' governed by logic and demands for evidence and not technologies (Graziano & Raulin, 1993:5). Scientific activities are those including 'observing, collecting and classifying data, setting up and carrying out experiments, calibrating scientific instruments, constructing hypotheses, theories and models, and finding evidence…' (Nola & Irzik, 2005: 202). In this respect, Kranzberg (1991:235) distinguishes between "knowing why" (science) and "knowing how" (technology). Technology activities such as using an electron microscope or a running a computer program are not scientific and do not make one a scientist (Graziano & Raulin, 1993).

Science is generally perceived by the average person to offer 'hard facts, definite conclusions, and uncompromised objectivity'; therefore, any discipline classified as 'science' or 'hard science' enjoys a certain legitimacy and credibility from society's stance (Inman & Rudin, 2001:4). Such legitimacy and credibility seems to be lost with professions which are termed 'soft sciences' (ibid, 2001).

Despite the various perceptions about science being a field of 'hard facts, definite conclusions, and uncompromised objectivity', science is not the "truth" (Inman &

Rudin, 2001:4). It is rather a process of inquiry to observe, test, and better understand repeating patterns, in an attempt to try to establish general rules which help describe and explain the physical universe (Graziano & Raulin, 1993).

In his famous book "Conjectures and Refutations: The Growth of Scientific Knowledge", Karl Popper, arguably the most well known science philosopher of the 20^{th} Century, asserts that science is characterised by being refutable (Popper, 1989). He asserts that scientific theories are inherently conjectures and subject to development through the unending process of trial and error. Such refutation is the paramount foundation of the scientific "discovery" and what distinguishes scientific knowledge and theories from non-scientific ones (Popper, 1989). In the revival of his book "The Logic of Scientific Discovery: 14^{th} Printing", Popper re-defends his stance on the refutability of scientific knowledge. He also defends his principle of falsifiability for determining whether or not a theoretical system belongs to empirical science or to other non- scientific domains such as metaphysics or pseudoscience (Popper, 2002).

Popper through his notion of "falsification" provides a new model of scientific inquiry. Such model focuses on conjecture and refutation to eliminate false theories rather than on the conventional model of scientific inquiry as a set of 'experiments to verify and confirm empirical propositions' (Bybee et al., 2008). Popper's notion of the refutability of scientific knowledge may provide resolutions to the arguments revolving around 'how scientific a number of forensic science techniques are". His notion may also challenge the science identity of forensic science practice, where evidence provided by forensic scientists in a court of law needs to be "beyond reasonable doubt"; i.e. not subject to refutations and conjectures.

Because science is historic and sociological, it is of great benefit to introduce in the literature review one of the leading scholars in the history, sociology, and philosophy of science in the 20^{th} century: Thomas Kuhn (Sharrock & Read, 2002). Through his research on the history of science, Kuhn argued that scientific practice alternates between periods of normal science and moments of revolutionary science. He asserted that "normal science" occurs when the scientific community relies on one or more scientific achievements and ‘a set of received beliefs’ which enable the community to assume that ‘[it] knows what the world is like’ (Kuhn, 1996: 4-5). During periods of normality, scientists tend to subscribe to a large body of interconnecting knowledge, methods, and assumptions which make up the reigning paradigm. This paradigm will incorporate a series of problems or "puzzles" that scientists attempt to solve with ‘passion and devotion’. The solutions to a number of these puzzles become well known and communicated amongst the scientific community. These common solutions are termed **exemplars** of the field (Sharrock & Read, 2002). In “The Structure of Scientific Revolutions”, Kuhn gave examples on what the term “exemplars” represents to a scientific community:

> *All physicists, for example, begin by learning the same exemplars: problems such as the inclined plane, the conical pendulum, and Keplerian orbits; instruments such as the vernier, the calorimeter, and the Wheatstone bridge* (1996:187).

Kuhn then emphasises that, during scientific development, a shift takes place from one paradigm to another when a new emerging theory seems to be better than its competitors. He refers to these moments as “scientific revolutions” (Sharrock & Read, 2002). During such moments, Kuhn asserts that as the new paradigmatic school grows in strength and in the number of advocates, the pre-paradigmatic schools fade:

> *When, in the development of a natural science, an individual or group first produces a synthesis able to attract most of the next generation’s practitioners, the older school gradually disappears. In part their disappearance is caused by their members’ conversion to the new paradigm... the new paradigm implies a new and more rigid definition of the field* (1996: 18-19).

Kuhn adopts the notion of “*avant-garde*” from arts into science (Kuhn, 1996). “*Avant-garde*” is a “ a French military term originally used to describe the foremost part of an army advancing into battle (also called the vanguard) and now applied to any group, particularly of artists, that considers itself innovative and ahead of the majority"[22]. Kuhn adopts this term to represent the advocates of the paradigm shift who become the forefront guards- *the avant-gardes*- of the new reigning paradigm (1996).

From Kuhn's standpoint, forensic science may be seen as a paradigm of interconnecting knowledge, methods, and assumptions. Such a paradigm incorporates a series of exemplars which may be useful for this research to investigate and identify.

Imre Lakatos, a science philosopher and student of Popper, criticised both Popper's notion of falsification and Kuhn's paradigm shift proposition (Maxwell, 2005; O'Raifeartaigh, 2011). Lakatos sought the reconciliation of the different notions of science held by both Popper and Kuhn (Maxwell, 2005). The result was a synthesis by Lakatos of the ideas of Popper and Kuhn in his concept of "progressive research programme" (Maxwell, 2005).

Lakatos argues that in science a theory is the result of research progression from slightly different preceding theories and experimental techniques developed over time (Motterlini, 1999). According to a number of scholars, Lakatos' concept of science developing as progressive research programme offers a more nuanced version of both Popper's and Kuhn's ideas (Maxwell, 2005; O'Raifeartaigh, 2011):

- Instead of theories being totally rejected at the first conflict with observation (Popper's falsifiability), science is seen through Lakatos' lens as proceeding by continually adjusting and developing preceding theories through research.
- A paradigm shift (Kuhn's notion) does not proceed in a revolutionary, irrational, manner but rather in a systematic process, where the shift occurs from a degenerative research programme to a more progressive one.

[22] "avant-garde" *The Concise Oxford Dictionary of Art Terms.* by Michael Clarke and Deborah Clarke. Oxford University Press Inc. *Oxford Reference Online*. Oxford University Press. Victoria University. 20 September 2010 http://0-www.oxfordreference.com.library.vu.edu.au/views/ENTRY.html?subview=Main&entry=t4.e1825

Thomas Kuhn responded to Lakatos' views and criticised his views of "rationality" and progressive research programme as neglecting scepticism in scientific inquiries, escaping a critical read of the history of science, and depriving the history of science of any 'philosophical function' (Kuhn, 142: 1970). Similarly, Lakatos' views were heavily criticised by Paul Feyerabend, another student of Popper (O'Raifeartaigh, 2011). Feyerabend criticised the orderly assumed manner through which science progresses in terms of Lakatos' "progressive research programme" (1975). Feyerabend argues that not all theories of science arrive as a progressive succession and developments of previous theories. There are theories which 'drop one or the other of the assumptions of the objectivists' (Feyerabend, 1975: 16). According to Feyerabend, Lakatos' concept does not cater to scepticism and assumes the world as orderly, objective, and rational as it wasn't and will never be!

A modern science philosopher who addressed all of Popper's, Kuhn's, and Lakatos' concepts is Nicholas Maxwell. Maxwell synthesised Popper's, Kuhn's, and Lakatos' ideas to develop his notion of **aim-oriented empiricism** (**AOE**) (2005; 2006). Maxwell's idea of AOE emerged from his belief of the need for a revolution in the philosophy of science which acknowledges that science comprises not only empirical considerations, but also a hierarchy of metaphysical assumptions which can no longer be avoided or overlooked (2002).

AOE is argued to go beyond the 'rational' and structured empirical scientific inquiries to cater for the 'ad-hoc' inquiries which exist along with the structured ones (Maxwell 2005, 2006). AOE also succeeds, where many other notions failed, in addressing the 'untestable metaphysical assumptions' about 'the unity, comprehensibility, and knowability of the universe', where many sciences (e.g. physics) have implicitly adopted these assumptions which became part of their paradigms or scientific knowledge (Maxwell, 2005: 181-182). AOE promotes explicitness about such metaphysical assumptions through offering a 7-level aim-oriented empiricism hierarchy, where such assumptions gain more truthfulness and hence explicitness as they proceed up the hierarchy (Maxwell, 2005, 2006).

Maxwell asserts that his notion of AOE addresses both the research empiricism of scientific theories (Lakatos) and commonly accepted assumptions which comprise the paradigm of a scientific community (Kuhn) in a modified refutation manner (Popper). AOE focuses on critical scrutiny and criticism rather than falsification (2005, 2006). Maxwell argues that his concept of AOE (2005: 186-188):

- Emerges from the modification of 'Popper's falsificationism to remove defects inherent in that position' so that scientific assumptions can be subject to greater critical scrutiny and criticism rather than falsification,
- Shares close features with Kuhn's reigning paradigms, where metaphysical assumptions during periods of 'normal science' become part of the body of scientific knowledge or the reigning paradigm, and
- Improves Lakatos' research programme methodology by providing means for the assessment of "hard cores" (Lakatos' paradigms) through processes other than the 'empirical success and failure of the research programmes to which they give rise".

Maxwell's AOE concept may be useful in responding to the dilemma a number of forensic science techniques suffers from. Unique forensic forms of inquiry such as fingerprinting and handwriting examination are criticised for their presumed unquestionable acceptance and assumed uniqueness, validity, and reliability as identification tools (Houck 2006 & Giannelli 2006). Maxwell's aimed-oriented empiricism hierarchy might be able to ease such a dilemma and offer these techniques more truthfulness and explicitness.

2.2.2.2- Science Education: Definitions & Contexts

"What counts as science education?" is an inquiry that Douglas Robert in "Development and Dilemmas in Science Education" was attempting to answer (Roberts, 1988). After a thorough discussion and analysis, he comes to the conclusion that the question requires a complex answer and should not be oversimplified by one-dimensional answers such as 'science education is the processes of enquiry' or 'science education is the promotion of scientific literacy', etc (1998:50). Stakeholders' (science teachers, science educators, students, parents, science departments etc) views of science impact the way science education is organised, taught, and assessed (Wellington & Ireson, 2008). The wider those views are about science, the more is the flexibility and comprehensibility of science education (Wellington & Ireson, 2008).

Science education over the last three decades has been moving away from a dogmatic perception of science only for the sake of science, in isolation of any social context (Duschl, 2008; Fensham, 1988; Roberts, 1988). Traditionally, science education focused on 'what one needs to know to do science' rather than 'how we need to know and why we believe' (Duschl, 2008: 269). Science education can no longer promote scientific inquires in isolation from personal needs and societal issues (Bybee et al., 2008). To emphasise the 'how we need to know' and 'why we believe', science education needs to promote learning environments which facilitate two important activities (Duschl, 2008:287):

- Visualising students' thinking through teaching and learning contexts which promote 'scientific reasoning and the motivation to learn' and

- Contextualising science education in manners which emphasise 'the conceptual, epistemic, and social dimensions of science'.

Science education, according to Roberts, possesses three dimensions (1988: 30):

- choices being made (science topics, what to teach, what not to teach, how to teach, how to motivate, etc),
- Decisions which support the choices being made from a practical stance rather than a theoretical one, and
- Contexts being constructed to tailor to individual needs and situations in every 'educational jurisdiction', school, and classroom.

Science education has always suffered from deficiencies in the learning process which can be summarised by: 1) ‘rhetoric of conclusions’ (De Vos et al., 2002), 2) incoherencies (Roberts, 1982; De Vos & Pilot, 2001) and 3) ‘lack of student input’ (Lemke, 1990). Amongst efficient remedies to these deficiencies is enhancing ‘meaningful’ science education which concentrates on: 1) connecting subject content to context (Rivet et al., 2000), 2) engaging students in actual science practice, and 3) paying attention to student input and acting accordingly (Westbroek et al., 2005).

Williams, Mauffette, and Ward (2001) assert that a call for change in science education has been gaining in popularity. The need for change in science education can be attributed to three factors:

i) *Increasing amount of new technologies and information* which impose drastic changes onto science education for the upcoming years (Cowdroy & Mauffette, 1999; Williams et al., 2001).
ii) *Ineffectiveness of traditional science courses* in actively engaging students and increasing their determination in the science field (Williams et al., 2001).
iii) *Diversity of domains of future careers* which impose on graduates the preparedness to pursue different domains within their career via undertaking several paths (Williams et al., 2001).

After exploring science literature, the research will introduce in the following section medical education as case study comparable to forensic science education. Curricular and pedagogical approaches adopted in medical education may be useful strategies to be considered within forensic science education.

2.2.3- A Comparative Case Study: Medical Education

Forensic science is similar to medicine on three levels:

- discipline-knowledge level,
- practice domains level, and
- a highly human activity level (legal and ethical)

On a discipline-knowledge level, both medicine and forensic science:

a. 'rest firmly on a foundation of the basic scientific principles of physics, chemistry, and biology' (Inman & Rudin, 2000:4), and
b. are pluri-disciplinary in nature, incorporating various fields of knowledge in a complex mating (Lary, Lavigne, Muma, Jones, & Hoeft, 1997).

On practice domains level, both medicine and forensic science cater to licensed practice domains which operate within the field. For example, within the medical field, a variety of licensed practice domains such as general practice, pathology, dentistry, neurology, and chiropractic exist. Similarly, within the field of forensic science, practice domains such as forensic chemistry, forensic biology, fingerprinting, handwriting examination, ballistics, and firearms operate. Hence, medical education may be considered a case study which offers comparative insights into forensic science education.

On a highly human activity level, both medicine and forensic science possess an integrated social and legal power at the core of their activity. They both have the direct relationship to human activities, accounting for all the ethical risks associated with such activities.

Undergraduate medical education has been urged by scholars to adapt to the changing needs of modern education (Walton, 1994). In *Tomorrow's Doctors*, the General Medical Council (1993) recommended revised curricula informed by 'modern educational theory', aimed at promoting curiosity-driven self-directed learning and critical appraisal of evidence. The *Report of the Working Party on Medical Education* (British Medical Association, 1995) asserts consensus on advocating a learning environment of medical education which encourages collaboration over competition, connection between theory and practical experience, learning choices and self assessment. Maudsley and Strivens (2000: 535) argue that the agreement on the need to develop and modify medical education curricula has provoked educational reflection in medical schools specifically highlighting conditions for:

- professional knowledge acquisition
- critical thinking, problem-solving and clinical problem-solving, and
- lifelong professional learning.

Different perceptions about the definition of good medical practice influence medical educators' choices about the preferred approaches to educating doctors (General Medical Council, 1998). Goode (1960: 902-14) perceives good medical practice as a practice 'receiving substantial income, power, and prestige, possessing strong identity and affiliation, and providing a lasting occupation'. After three decades, the General Medical Council (1993) perceived good medical practice as 'resolving problems, understanding and advancing the knowledge base… promoting health, and maintaining professional attitudes to both practice and education'. In this context, Eraut (1992, 1995) argued that professional and qualitative medical practice is possessed by medical practitioners through professional knowledge which includes: propositional knowledge (knowing that), practical knowledge (knowing how), personal knowledge and moral principles.

Throughout history, medical education has been the subject of three main curricular approaches:

i- The multidisciplinary approach: multidisciplinary integration in medical education allows for 'each discipline to independently contribute its skill to patient's care' (Hall & Weaver, 2001: 867-875). This approach involves independent decision-making by a "gatekeeper" faculty member. This faculty member is mainly concerned with what other disciplines contribute to the course structure rather being concerned with coordination of information (Garner, 1995).

ii- The interdisciplinary approach: interdisciplinary integration in medical education optimizes care for the patient (Hall & Weaver, 2001). Such an approach organises team work, knowledge, and skills around solving a common set of problems rather than around a single physician as in the multidisciplinary approach (Clarke, Spence & Sheehan 1996).

iii- The transdisciplinary approach: In transdisciplinarity, professional functions overlap (Hall & Weaver, 2001). In such an approach, each member of a medical team must acquire sufficient knowledge about the concepts and approaches of their colleagues in order to assume significant portions of their roles (Hinton, Walker, Baldwin, Fitzpatrick, Ryan, Bulgar and Debasio 1998). This approach 'promotes efficiency in delivery of educational or health care services' (Dyer, 2003: 186-187).

As for pedagogies, there have been two main pedagogical approaches in medical education: the conventional lecture-based learning (LBL) approach and the problem-based learning (PBL) approach (Williams & Duch, 1997; Allen & Duch, 1998; Doucet, Purdy, Kaufman, Langille, 1998:590; Colliver, 2000: 259-66; Norman & Schmidt, 2000: 721; Albanese, 2000:729).

PBL has its origins in the early seventies when new medical schools were established and problem-based learning was integrated within the curricula of these schools (Barrows, 1996). Since then, PBL has been well applied in medical education training programs (Jonas, Etzel, & Barzansky, 1989).

Prince, van Mameren, Hylkema, Drukker, Scherpbier, and van der Vleuten (2003: 15) argue that in PBL, learning takes place in a 'meaningful and authentic context' for students in practice learn to 'connect clinical phenomena to underlying basic science concepts'. Jones, McArdle, and O'Neill (2002: 16-25) asserts that introducing PBL in medical education curriculum has changed the profile of the perceived preparedness of graduates for entering professional practice.

Whilst some scholars have argued the effectiveness of PBL as being uncertain (Kelly & Cantillon, 2003), non-convincing (Colliver, 2000), and as a non-comprehensive educational strategy as LBL (Kim et al., 2000), many other scholars have researched and defended the effectiveness of PBL in medical education. Albanese and Mitchell (1993), after reviewing all literature published on this topic from 1972-1992, argued that PBL graduates, although scoring lower on basic science examinations, performed the same and sometimes better than LBL graduates on clinical examinations and faculty evaluations. Prince et al. (2003:15) conducted a study about the possibility that PBL might lead to deficiencies in basic science knowledge. The study researched eight medical schools in Netherlands which have adopted either PBL or non-PBL techniques. The study investigated the possibility that PBL might lead to deficiencies in basic science knowledge. They found that PBL students have the same perceived level of anatomy knowledge as students taking more traditional educational approaches. In a similar study, Verhoeven, Verwijnen, Scherpbier, and van der Vleuten (2002) investigated the growth in student knowledge over the course of the Maastricht Medical School’s 6-year problem-based curriculum. Verhoeven et al. based their study on the argument that the degree of acquisition of knowledge by students is one of the measures of the effectiveness of a medical curriculum. They found that overall, medical knowledge and clinical sciences knowledge demonstrated a steady upward growth curve. However, the results for years 5 and 6 show diminished growth in basic and behavioural/ social sciences knowledge suggesting that there were discrepancies between actual and planned curricula. Verhoeven et al. (2002) concluded that as a result of such an outcome, further research is needed.

In a study about student feedback in problem based learning, Parkish, McReelis, and Hodges (2001) surveyed 103 final year students across five PBL Ontario medical schools to determine the types of feedback that students received in those schools. Parkish et al (2001) found that there exist significant differences in the types of feedback student received in the five schools, and that the use of peer feedback and self-assessment is limited in most schools. In another study, Jones, McArdle, and O’Neill (2002) conducted a comparative study between the 1998 Manchester graduates (the last group of graduates of the conventional medicine course) and 1999 Manchester graduates (the first group of graduates of the newly introduced PBL curricular approach) about the differences in perceptions of how well graduates are prepared for the role of pre-registration house officer. After surveying both the "traditional course" graduates and the "PBL course" graduates, Jones et al. found that the "PBL course" graduates rated their understanding of disease processes lower than that of the 'traditional course' graduates. However, educational supervisors rated "PBL course" as better preparing graduates in some of the competencies and specific skills listed by the General Medical Council. They conclude that 'a major change in curriculum approach has changed the profile of the perceived preparedness of graduates for entering professional practice' (Jones et al., 2002: 25). A similar study was conducted by Mavis and Wagner (2006) on second-year medical students at Michigan State University who were exposed to both traditional lecture-based learning (during 1st year) and PBL (during 2nd Year). Mavis and Wagner (2006:126) argued that although students favoured LBL for 'efficiency and direct learning', they valued and endorsed PBL for 'breadth of learning and enhancing interpersonal skills'.

A current example on the introduction of PBL within medical curricula is the University of Newcastle, Australia. According to the Australian Medical Council report, the University of Newcastle is one of the Australian leaders in introducing problem-based integrated medical curriculum (2003). The Newcastle curriculum is 'based upon principles of scientific method and evidence-based practice', and inculcates analytical and critical thinking through PBL (ibid:12). The report (2003:11) argues that the guidelines of the Newcastle course emphasise small group learning, gradual independence in learning, and the use of contemporary clinical problems as a basis for such learning. The report also notes that the Newcastle course emphasises self-directed and independent learning, inculcates analytical and critical thinking, and ensures relevance of content to clinical medicine.

Another innovative example of the adoption of PBL in medical education is the experience of the Faculty of Medicine in the University of Hong Kong which was launched in 1997. The University of Hong Kong (UOHK) considers that PBL, as an education strategy, is adequate to cope with future demands in medicine. These demands are mainly: 'the challenge of life-long learning and the ability to search out and assimilate new knowledge as it becomes necessary' (UOHK, 2008:2). Traditional LBL fails to cope with such demands as this strategy mainly provides medicine students with a 'fund of information' which is no longer sufficient to cope with 'the new understandings of the biology of health and disease', 'the development of diagnostic technology', and 'the therapeutic and surgical procedures that currently seem revolutionary' (UOHK, 2008:2). Medicine students- including forensic medicine students- at the University of Hong Kong learn about medicine as they 'attempt to deal with real-life medical situations' (UOHK, 2008:2). Hence, PBL is a survival educational strategy for tomorrow's doctors (UOHK, 2008).

A third example is the experience of Queen's University in Canada. The introduction of PBL within the medical curriculum at Queen's University comes as an appreciation for the interconnected nature of the biological, physical, and behavioural mechanisms which constitute the solution of every health problem (Delva, 2003). By participating in such a learning format, students will become 'proficient in the process of problem analysis, hypothesis generation, and the generation of learning issues that warrant further exploration' (Delva, 2003:1).

Discussion about PBL in medical education is an ongoing debate and area of research. The debate is mainly between two opinions. The first opinion argues that PBL represents an appropriate curricular form that fulfils the changing needs of knowledge and practice in medical education (Maudsley & Strivens, 2000: 535). PBL students maybe better prepared to apply basic science concepts in practice (Boshuizen & Schmidt, 1992: 153-84), may retain their knowledge over a longer period of time (Eisenstaedt, Barry & Glanz, 1990: 11-14), and maybe better equipped to keep up with the development of medical knowledge (Shin, Haynes & Johnston, 1993: 969-76). The second opinion, doubts the effectiveness and the comprehension of PBL and the gaps it may generate in the knowledge base of graduates (Kelly & Cantillon, 2003; Colliver, 2000; Kim et al., 2000). During the 4th Meeting of the Mediterranean Academy of Forensic Sciences in Turkey, Associate Professor Philip Beh, the coordinator of the

PBL approach in forensic medicine at the University of Hong Kong, argued that 'even if PBL generates gaps in the knowledge of the students, such approach remains very effective as it graduates students who learn how to learn, what to learn, and how to overcome those gaps or deficiencies in their knowledge' (2009).

The curricular approach under which medical education needs to be organised and the pedagogical approach through which medical knowledge needs to be transmitted remain areas of debate and discussion. These debates and discussions create insights into similar debates and discussions which are likely to take place within forensic science education. In other words, current curricular and pedagogical researches which have been adopted in medical education may be related to forensic science education which has similar complex characteristics of knowledge, practice, and identity.

Forensic science education, given its similarity to medical education, may be exposed to debates about the curricular approach, disciplinary integration, and pedagogy needed to set, organise, and deliver such an education. Hence, the following subsections will examine the literature pertaining to the different curricular and pedagogical approaches within education.

2.2.4- Curricular Integration

Since the 1990s, new 'disciplines'- better described as cross-disciplines- such as media studies, informatics, and forensic science have emerged as a result of the universal tendency towards integration among disciplines and publicizing knowledge distribution and production (Blewitt, 2004).

Integration is a 'philosophy of teaching in which content is drawn from several subject areas to focus on a particular topic or theme' (McBrien & Brandt, 1997:55). Integrated curriculum is 'about making meaningful connections between topics or skills that are usually addressed in different subject areas (ASCD[23]: 1997)**.** In this context, Basil

[23] ASCD= The Association for Supervision and Curriculum Development

Bernstein, an education sociologist, defines integration as a ‘term which refers minimally to the subordination of previously insulated subjects or courses to some relational idea, which blurs the boundaries between the subjects’ (1977: 93). This relational idea, according to Bernstein, is ‘a supra-content concept which focuses upon general principles at a high level of abstraction’ between two or more disciplines (1977: 101).

Bernstein is well known for his notion which relates curricular integration to social attributes and changes (1977; 2000). In volume 3 of “Class, Codes and Controls: Towards a Theory of Educational Transmissions”, Bernstein attributed the changes in contemporary educational systems to changes in ‘social integration’ and ‘social solidarity’ (1977:101). He emphasised two major forms of social solidarity (1977:101):

- ‘Mechanical solidarity’ which exists wherever individuals share a common system of beliefs, opinions and attitudes.
- ‘Organic solidarity’ which exists wherever differences between individuals relate to each other to express achieved roles.

Bernstein (1977:80-82) argues that these two forms of social solidarity are reflected in education in two broad types of curriculum: collection- code type curriculum and integrated- code type curriculum. In his more recent book: “Pedagogy, Symbolic Control and Identity”, Bernstein re-emphasises his notion of curricular integration as a reflection of social solidarity and compares the collection- code type curriculum with the integrated code curriculum (2000) as summarised in Table- 2a.

Jacobsen (1981) conducted theoretical elaboration and empirical investigation on Bernstein’s two curricular paradigms within higher education. He conducted his research on two universities: one which adopted firmly structured curriculum (collection-type curriculum) and the second which adopted loosely structured curriculum (integrated-type curriculum). Jacobsen found that these two types of curriculum showed ‘marked differences’ on four levels: ‘society, institution, teaching situation and the level of the individual’ (p. 25).

Educators who support collection-code type curriculum attribute their support to the assumption that ‘students learn best when the content is broken down into small steps and separated into logical subdivisions’ (Campbell & Harris, 2001:3). On the other hand, educators who support integrated-code type curriculum back up their support with the belief that students learn best when knowledge is acquired through complex tasks which interconnect ideas rather than isolate them (Campbell & Harris, 2001). For instance, Pinar argues against traditional disciplinarity as there is no any educational reason why subjects ‘must be kept compartmentalized within aggressively patrolled disciplines’ (Pinar, 2004:227). However, he admits that integrated fields of knowledge face more epistemological struggles than traditional disciplinary field. This is because integrated fields of knowledge require more reconceptualisation of the curriculum and more complex discourse between various curricular stakeholders (Pinar, 1988b; 2004).

	Collection-Code Type Curriculum	Integrated-Code Type Curriculum
Overall Approach	**‘education in depth’**	**‘education in breadth’**
Social Implication	**mechanical solidarity**	**organic solidarity**
Unifying Principle	**subject or discipline**	**theme or topic**
Contents	**high- status contents stand in a ‘closed relation’ where subjects are clearly bounded and separated**	**high- status contents stand in an ‘open relation’ to one another**
Syllabus	**syllabus of each content is under the authority of the academics delivering these contents**	**syllabus is subordinate to a general idea which is ‘supra-subject’ and which governs the relationship between subjects**
Pedagogy	**individual pedagogies which proceeds from the surface structure of the knowledge to the deep structure**	**common pedagogies which proceed from the deep structure to the surface structure**
Knowledge Emphasis	**emphasis on states of knowledge**	**emphasis on ways of knowing**
Structure	**rigid, differentiating, systematic, and hierarchical**	**flexible and promoting students’ engagement in curriculum planning and development**

Table-2a: collection-code type curriculum versus integrated-code type curriculum (Bernstein, 1977, 2000)

2.2.4.1- Reasons for Integration

The shift from collection-type curriculum to integrated-type curriculum may be attributed to:

- A shift of emphasis in principles of social integration- from mechanical to organic solidarity (Bernstein, 1977);
- The argument that traditional disciplines/ closed courses are obsolete and lead to redundant fragmentation of knowledge (Warwick, 1975);
- The belief that 'knowledge, as opposed to mere information, is becoming increasingly rooted in specific contexts of application that go beyond the rules and perspectives of single subject disciplines' (Blewitt, 2004:2);
- The crucial need for bridges between many of the different disciplines which have emerged in the 20th century (Nicolescu, 1998);
- Society's response to growth of knowledge and relevance of curriculum (Jacobs, 2000);
- The increased demand to set liaison between ideas and work in diverse groups in many contexts (Frazee & Rudnitski, 1995); and/or
- The continuous and increased demands for connecting and relating ideas, topics, and disciplines in the 21st century (Drake & Burns, 2004).

2.2.4.2- Forms of Curriculum Integration

Bernstein (1977, 2000) argues that collection-type curriculum and integrated-type curriculum are only broad hypothetical categories, because, practically speaking, it is not possible to have absolute closeness/separation or absolute openness/integration between various subjects (contents) of an academic program. Therefore, collection-type curriculum and integrated-type curriculum form the range/ boundaries within which various types of curricula fall.

There are many various forms of curricular approaches possessing differences in content separation/integration the major and most common of which are:

2.2.4.2.1- Discipline-Based Curriculum

Discipline-based curriculum is a curricular approach which traditionally focuses on subjects as separated units (Jacobs, 1989). This type of curriculum is the least integrated, where subjects are taught separately with minimal coordination and cooperation amongst teachers/lecturers of different subjects (Frazee & Rudnitski, 1995). Students graduating under such a curriculum enjoy strong theoretical background; however, they may face difficulty in solving many real-world problems which are interdisciplinary in nature (Frazee & Rudnitski, 1995). Despite the universal trend towards integration and transdisciplinarity especially in handling new emerging specialisations, disciplinarity dominance remains vital in the 'cultural reproduction of knowledge' and in maintaining an 'intellectual axis for comprehending contemporary developments' (Blewitt, 2004:1).

2.2.4.2.2- Multidisciplinary Curriculum

Multidisciplinary courses are implications of the new curricular approaches in education that are 'hard to see' via the traditional disciplinary-based curricular approaches in education that find it 'hard to die' (Geisler, 2002:8). This curricular approach, similar to discipline-based curriculum, focuses primarily on the disciplines (Drake & Burns, 2004); however, it organises principles and contents of the various subjects around a theme, leading to a low-level curricular integrative touch (Frazee & Rudnitski, 1995). This approach examines contents through a number of disciplinary lenses (ASCD[24], 1997). However, the nature of the disciplines used remains distinct and only the methods of one major discipline will be adopted (Geisler, 2002). In this approach, a "gatekeeper" faculty member controls which other disciplines may be invited for content examination (Garner, 1995). In conclusion, this approach is more concerned about the achieving of specific discipline aims rather than the coordination of information among various disciplines (Garner, 1995; Hoeman, 1996).

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[24] ASCD= Association for Supervision and Curriculum Development

2.2.4.2.3- Interdisciplinary Curriculum

Interdisciplinary curriculum is a 'knowledge view and curricular approach that consciously applies methodology and language from more than one discipline to examine a central theme, topic, issue, problem, or work' (Jacobs, 1989:5). This curricular approach is governed by an 'overarching' theme which is explored and developed through: 1) broad applications to all disciplines (Lutes, 2001), 2) connections among various disciplines (Jacobs, 1989), 3) mutual communication between disciplines (Diller, 1990), and conceptions that cut across disciplines (ASCD, 1997). Disciplines in this approach are still 'identifiable, but they assume less importance than in the multidisciplinary approach' (Drake & Burns, 2004:12).

2.2.4.2.4- Transdisciplinary Curriculum

Transdisciplinary curriculum is the most integrated approach of all (Frazee & Rudnitski, 1995). It is the approach which operates 'between disciplines, across different disciplines, and beyond all disciplines' (Nicolescu, 1998:1), thus combining all the processes of multidisciplinarity and interdisciplinarity (Ramadier, 2004). This curricular approach is a 'real-life context' where most of the disciplines are embedded within the topic of study (ASCD, 1997). One of the major distinguishing factors in this approach is that students constitute an integral part of curriculum development through their ideas, questions, concerns, and experiences (Lutes, 2001).

Transdisciplinarity is characterized by: 1) confronting and dealing with 'complex and heterogeneous domains' (Lawrence, 2004; Horlick-Jones & Sime, 2004), 2) challenging 'knowledge fragmentation' (Klein, 2004; Ramadier, 2004), and 3) moving beyond any academic disciplinary structure through its 'hybrid nature, non-linearity, and reflexivity' (Balsiger, 2004).

In curriculum delivery, the teachers/lecturers should not adopt one curricular approach isolated from the others (Drake & Burns, 2004). For example, a teacher/lecturer adopting a discipline-based curriculum should allow for a fragment of integration or cross-disciplinarity as there are skills (e.g. problem solving, systematic thinking, inquiry, research, etc) that may only be acquired through integration. Similarly, a teacher/lecturer adopting an integrated-based curriculum should emphasise some disciplinarity as there are some core and fundamental knowledge, theories, and skills that may only be covered through disciplinarity (Drake & Burns, 2004).

Medical education, as a comparative case study to forensic science education, suggested the possibility of applying various curricular and pedagogical models. In this subsection, various curricular models have been examined. In the following subsection, various pedagogical approaches are explored.

2.2.5- Pedagogies and Learning Approaches

In the 21st century, some scholars emphasise that learning should be approached from four dimensions: 1) learning to do, 2) learning to know, 3) learning to be and 4) learning to live together (Blewitt, 2004). Ramsden (1988) argues that learning strategies may be constrained by three related contextual domains: teaching (method of transmission), the assessment (method of evaluation) and the curriculum (method of content delivery).

Learning- as a method of instruction- exists in various formats of which there exist three main types: lecture-based learning, problem-based learning, and practice-based learning.

2.2.5.1- Lecture-Based Learning (LBL)

LBL is a method of instruction where the lecturer (instructor) occupies the most important and vital role in the knowledge-transmission process. Hence, the lecturer represents the centre of attention and the source of momentum for students (Ekeler, 1994). LBL is more associated with collection-type curriculum (e.g. conventional discipline-based and multidisciplinary curricular approaches), whilst less correlated with integration-type curriculum (e.g. interdisciplinary and transdisciplinary curricular approaches) (Drake & Burns, 2004). LBL is applied through one of three major forms (Ekeler, 1994):

- Formal lectures where lecturers present their ideas in a highly structured manner and expect/receive no active participation from their students, i.e. audience.
- Informal lectures which are not as structured as the 'highly formal-type lecture' and where lecturers expect questions and may receive active participation through knowledge transmission from their students.
- Feedback lectures which combine conventional structured methods of instruction with other teaching methodologies, offering room for students' discussions, feedback and input.

LBL can be characterized by the following features (Campbell & Harris, 2001:5):

- Learning takes place in small consecutive steps which start with preparing students, emphasizing aims and objectives of lectures, defining terms, presenting lecture materials, applying knowledge, and which end up with summary and evaluation.
- Learning moves from the simplest to the most complex ideas;
- Disciplines are often treated separately;
- Ideas are developed in a tight, systematic, logical sequence;
- Skills are taught deliberately and in isolation where the complex ones are delayed until sub-skills have been learned;
- Learning is self-placed; and
- Lecturers/ instructors are the directors and the decision-makers of the process, whilst students are the receptors.

Some of the advantages versus some of the disadvantages of LBL as a method of instruction are detailed in Table-7b (Ekeler, 1994:88-90). Despite all criticisms, LBL has always been the most frequently and widely used method of instruction in colleges and universities for many reasons, the most important of which is that it is the least expensive type of instruction (Ekeler, 1994).

Advantages of LBL	Disadvantages of LBL
The lecturer is the centre of attention; hence, s/he cannot divert students' attention to hide/escape from an uncertain answer, limited knowledge, or weak lecture preparation.	The lecturer is the centre of attention, controller, and decision maker of the teaching and learning process, whilst the student is only a knowledge receptor. This makes LBL inferior to other teaching approaches in developing students' problem-solving competencies.
LBL is useful in: 1) supplying students with various view points and scholarly arguments, 2) modelling 'correct thinking processes within a discipline for the students' and 3) stimulating students to undertake academic research.	This method treats students as a unity neglecting differences of 'interests, knowledge, skills, and intellectual abilities of those students'.
LBL is an easily understood method of instruction which effectively covers more content than almost any other teaching approach.	LBL often doesn't allow for 'immediate feedback about its effectiveness'.
LBL 'provides students with a complete logical structured approach to an academic discipline'.	LBL does not provide 'for long-term recall of subject matter'.
LBL is less expensive than any other method of instruction.	Students are either inactive whilst receiving knowledge in highly formal-type lecture or dominated by few of their fellows who are able to direct questions to the lecturer.

Table-2b

2.2.5.2- Problem-Based Learning (PBL)

PBL is defined as 'focused, experiential learning organised around the investigation and resolution of messy, real-world problems' (Torp & Sage, 1998:14). Clarke et al.[25] (1998: 5) define PBL as 'authentic learning where students are driven to develop and test solutions to real problems'. Delisle (1997:1) describes PBL as a 'discovering-learning process' which helps students internalize learning and gives them the chance to develop their own questions and investigative techniques. Maggi Savin-Baden

[25] (Clarke, Sanborn, Aiken, Cornell, Goodman, & Hess, 1998: 5)

argues that PBL is not only a teaching and learning strategy, but also a curricular approach in its own entity, context, and culture, where team learning and active learning practices are promoted (2003).

Throughout the literature, many educators have argued the significance of learning through problem solving and the significant concepts and knowledge that a student may acquire through this method of learning. Barell (1995:131) mentions that ‘Problematic situations are robust in that they contain within them significant concepts worth thinking about’. John Abbott (1996) argues that the new competencies (e.g. abstraction, systems thinking, experimentation, and collaboration), which are essential for our ever-changing world go far beyond the old- but necessary- competencies (e.g. numeracy, literacy, calculation, and communication). These new competencies can be successfully acquired through the ability to conceptualise problems and solutions (Abbott, 1996).

Learning occurring in conventional teaching methods often includes listening, writing, observing and memorizing; whereas, learning taking place in PBL incorporates a much broader type of knowledge acquisition and application including active thinking, performing and experiential learning by trial and error (Barrows & Tamblyn, 1980). In the same context, Hmelo-Silver (2004) argues that psychological research and theory suggest that learning through a problem solving format facilitates learning not only of content, but also of thinking strategies. Over the last three decades, ‘the framework for understanding the psychological basis of learning has shifted gradually from a teacher-centred approach to a student-centred approach’ drawing more attention and prominence to PBL (Sungur & Tekkaya, 2006:307).

Delisle (1997: 1) argues that problem-based learning is not a new invention because it can be traced back to the ‘progressive movement’ reflected in John Dewey’s traditions:

> *Methods which are permanently successful in formal education…go back to the type of situation which causes reflection out of school in ordinary life. They give pupils something to do, not something to learn; and the doing is of such a nature*

as to demand thinking, or the intentional noting of connections; learning naturally results (1944: 154, in Delisle, 1997)

It can therefore be argued that Dewey established the pedagogical framework of problem-based learning through the concept of natural learning which occurs when students are exposed to real life situations/problems and start investigating knowledge and connecting ideas (Delisle, 1997; Humelo-Silver, 2004).

Medical education was the first discipline to accommodate PBL and apply it in the 1960s (Jonas, Etzel & Barzansky, 1989; Savin-Baden, 2003). Since then, PBL has spread throughout the northern regions of America and other parts of the world (Albanese & Mitchell, 1993). It has since been applied to other health science curricula such as dentistry (Branda, 1990), occupational therapy (Salvatori, 2000) and nursing (Forbes & Prosser, 2001). PBL has expanded and has been applied to many other disciplines such as business, education, architecture, law, engineering, social work (Savery & Duffy, 1995), mathematics, science, chemical engineering (Wilkerson & Gijselars, 1996), counselling (Stewart, 1998), and psychotherapy (Sunblad, Sigrell, John & Lindkvist, 2002). The expansion of PBL into various academic disciplines can be attributed to the promise of the approach in assisting the achievement of educational goals which traditional pedagogies struggle or fail to do (Savin-Baden, 2003).

In PBL, students are exposed to a complex problem where they work in groups in coordination with the teacher, who plays the role of the coach or facilitator to: 1) identify the problem, 2) identify the knowledge base and competencies required to solve the problem, 3) engage in self-directed learning, 4) apply their new identified knowledge to the problem and 5) reflect on what they have learned and the effectiveness of the strategies adopted (Hmelo-Silver, 2004). Torp and Sage (1998:15) represented PBL process by the following paradigm (Figure-2b).

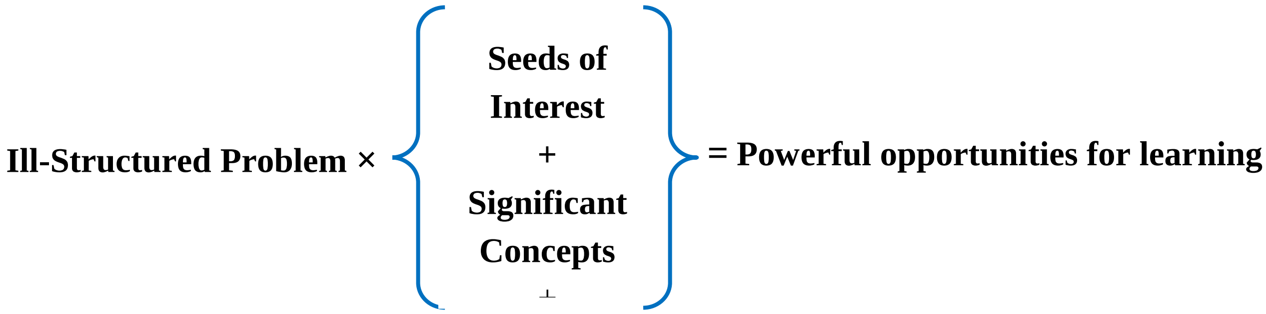


Figure-2b

Clarke et al. (1998: 5) point out in Figure-2c four phases of the learning inquiry which PBL demonstrates:

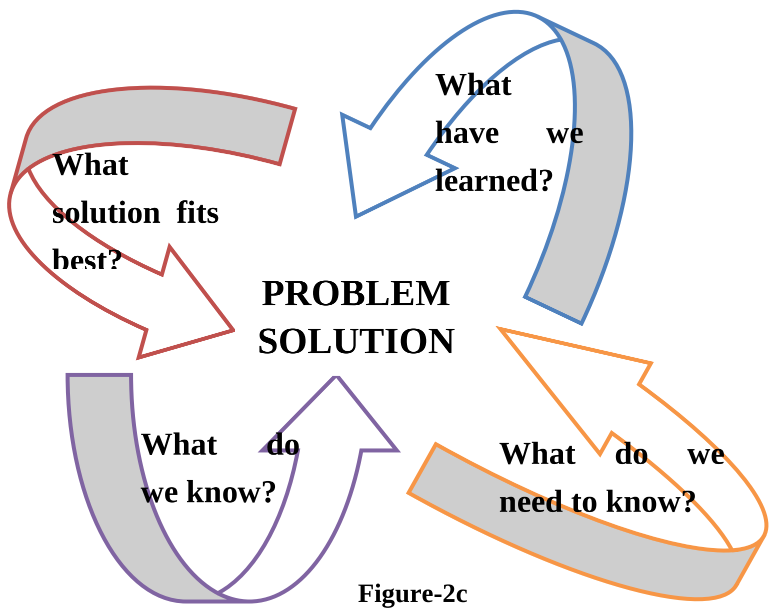


Figure-2c

Delisle (1997) argues that when curriculum is conceived as PBL, problems become ‘vehicles’ through which students acquire knowledge from a variety of disciplines. In PBL, the considered problems ‘promote the acquisition of appropriate skills and content knowledge found in the district’s frame-works or the teacher’s curriculum’ (p. 22). Delisle ends his argument by emphasizing that good problems combine student’s lives, interests, and daily activities with topics from the course syllabus, hence creating real-life contexts.

Despite the fact, that its initiators were medical educators with minimal knowledge in education and educational psychology, PBL through its development as a concept, strategy, and a reflective approach connects with important theories of learning such as the behavioural, cognitive, developmental and humanistic approaches (Savin-Baden & Major, 2004). Torp and Sage (1998:71) argue that PBL implements a three-dimensional model (Figure-2d) of cognitive processing: cognition, metacognition, and epistemic cognition. They emphasise that at the cognitive level, the students perceive and comprehend information; at the metacognitive level, the students monitor their own thinking and consider appropriate strategies; and at the epistemic cognitive level, students acquire knowledge about the limits, certainty, and criteria of knowing. Hence, PBL provide students with opportunities to become 'independent inquirers, who see learning and epistemology as flexible entities and perceive that there are also other valid ways of seeing things besides their own perspective' (Savin-Baden & Major, 2004:45).

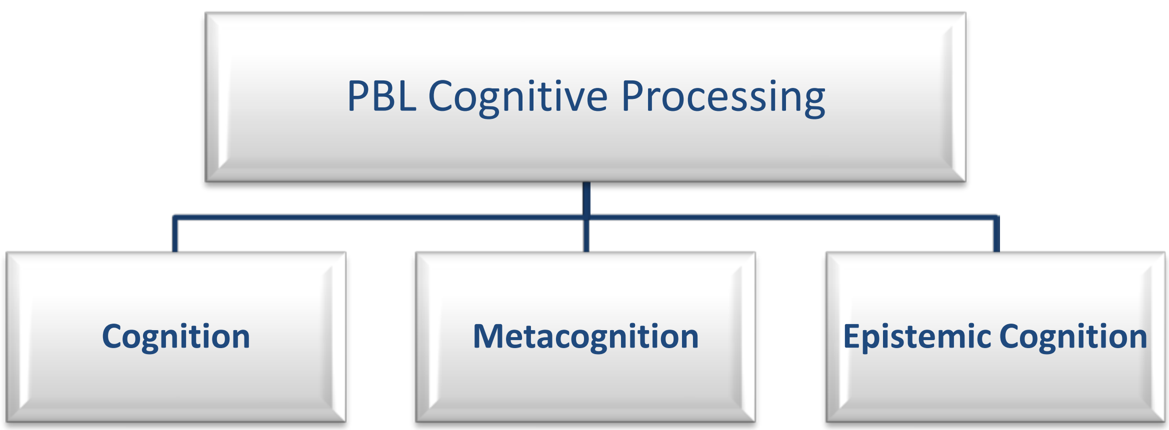


Figure- 2d

PBL is an 'authentic way to learn as it forces students not only to call upon the cognitive domain, but also to place demands on the affective and psychomotor domains of knowledge; areas often left unchallenged by didactic teaching' (Davis, 2006:246).

PBL emphasises the amount of knowledge that explicitly needs to be provided for higher education students in a specific syllabus or topic and sets out a framework through which students can better relate theories to real-life problems (Lam, 2004). PBL- compared to LBL- is argued by many scholars to improve critical thinking, communication, mutual respect, teamwork and interpersonal skills and to increase students' interest in a course (Gordon, Rogers, Comfort, Gavula & McGee 2001; McBroom & McBroom 2001; Sage 1996; Savoie & Hughes 1994; West 1992). PBL is characterized by the following features:

a. 'Learning is student centred';
b. 'Real-life problems form the organizing focus and stimulus for learning';
c. 'Problems are vehicles for the development of experiential knowledge and problem-solving skills' (Barrows, 1996:5);
d. Students are offered 'opportunities to learn how to learn' (Savin-Baden, 2000:146);
e. Students engage in self-directed learning to acquire new information under the guidance of the teacher who plays the role of the coach or facilitator rather than knowledge provider (Barrows, 1996; Hmelo-Silver, 2004);
f. Students engage in 'active and transferable learning'; and
g. 'Students develop flexible understanding and lifelong learning skills' (Hmelo-Silver, 2004: 235).

PBL, in higher education, usually takes place in small tutorial groups, as opposed to conventional LBL. In PBL, students learn to become independent learners (Lam, 2004). They learn by first drawing on their previous learning and personal knowledge to analyse the presented problem, then deciding on their own learning priorities, and finally setting the means of acquiring information to resolve the problem (Lam, 2004).

PBL currently enjoys worldwide agreement on being an innovative unique-featured approach in education (Boud & Feletti, 1997) and a major route for curricular integration (Drake & Burns, 2004). The extent of adoption of PBL- the whole curriculum, part thereof, or just a single subject- may be an issue of non-consensus

(Boud & Feletti, 1997). However, attempting to develop a collection-code curriculum which is based on high disciplinarity and isolation between subjects through a PBL approach will end up in a “disaster” (Savin-Baden & Major, 2004). Adopting PBL is not always a so obvious process as it might encounter complexities related to the nature of the discipline, the organisational culture, the structure of the curriculum, and/or students’ understandings, concerns, and needs (Savin-Baden, 2000). To be effective, PBL needs to be viewed as a curricular approach and situated in a team learning “context and culture” rather than just be offered as an occasional or an ad-hoc strategy (Savin-Baden & Major, 2004).

2.2.5.3- Practice- Based Learning

Practice-based learning is learning that takes place within the ‘practice setting’, i.e. within the workplace (Cross, Moore, Morris, Caladine, Hilton and Bristow, 2006). The practice setting is the paramount setting where *procedural knowledge* (Anderson, 1982) or knowing how and *propositional knowledge* can be acquired and reflected upon (Beckett & Hager, 2002; Billet, 2001; Cervero, 1992). These two forms of knowledge, which may not be acquired through conventional university settings, are indispensable for effective proficient practice (Beckett & Hager, 2002; Billet, 2001; Cervero, 1992).

Knowing how within practice is referred to as *tacit knowledge* (Brown & Duguid, 2001). Tacit knowledge is silent knowledge (Sapienza, 2002) grounded in experience (Horvath et al., 1999) and may be cultivated, acquired, and expressed through practice (Nestor-Baker & Hoy, 2001). It is the knowledge which cannot be easily put into words and comprises all the practical knowledge, practical competencies, and craft secrets of a given field (Beckett & Hager, 2002). Tacit knowledge consists of embodied expertise: ‘a deep understanding of complex interdependent systems that enables dynamic responses to context-specific problems (Wenger, McDermott & Snyder, 2002: 9). Tacit knowledge is argued to be equally important as explicit knowledge within the knowledge dichotomy (Brown & Duguid, 2001; Polanyi, 1966). Practitioners at different levels of a hierarchy of expertise possess different tacit knowledge competences (Doak & Assimakopoulus, 2006). It has been found that the 'difference between experts and novices is related to their inventory of tacit knowledge' (Sternberg, 2000:122). Tacit knowledge is vital for the development of professional practice and can be a source of highly effective performance in the workplace (Sternberg & Horvath, 1999).

Tacit knowledge is 'embedded in holistic work process, is implicitly gained, and is an integral part in the accomplishment of working tasks' (Herbig, Bussing & Ewert, 2001:690). Hence, such knowledge is much more likely to be emphasised and cultivated through the implicit informal practice-based learning settings, such as workplace learning setting, rather than explicit formal learning settings, such as classroom setting (Beckett & Hager, 2002).

Practice-based learning has long existed but was left disregarded, until recently because of the dominance of the 'standard paradigm of learning' which catered only for formal learning settings (Beckett & Hager, 2002). Until the second half of the twentieth century, the assumptions that 'work is what follows from formal learning experiences and the most valuable learning is the standard paradigm of learning' have governed educational thought (Beckett & Hager, 2002:98). This assumption had long survived through the traditional focus of Western education on 'Platonic epistemology and on Cartesian ontology, both of which emphasise theory over practice' (Beckett & Hager, 2002: 52). Thus other forms of learning, including practice-based learning, have been appraised by how well they approximate to the standard paradigm of learning. The differences between formal learning activities of all kinds and practice-based informal learning are detailed in Table-2c (Beckett & Hager, 2002:128).

Formal Learning	Informal Practice-Based Learning
Single capacity focus, e.g. cognition	Organic/holistic
Decontextualised	Contextualised
Passive spectator	Activity- and experienced-based
An end in itself	Dependent on other activities
Stimulated by teachers/trainers	Activated by individual learners
Individualistic	Often collaborative/collegial

Table- 2c

The features of informal practice-based learning have contributed in the emergence of formal work-based learning degrees which initiated discussions amongst higher education theorists to make sense of work as a curriculum (Boud & Solomon, 2001). Practice-based learning currently plays an imperative and indispensable role within higher education (Beckett & Hager, 2002; Billet, 2001; Lam, 2004). Practice-based learning may exist in various forms, the two major of which are field practicum and workplace learning.

2.2.5.3.1- Field Practicum

Field practicum is one form of practice-based learning (Cross et al., 2006) which takes place within higher education as either a part of foundation degree programs (Foskett, 2003), or of bachelor/ honours programs which involve a placement year or equivalent within their curriculum (Anema & McCoy, 2009). Field practicum often requires students to finish some core theoretical studies at their education institutions before they are referred to an agency or workplace relevant to their course of study (Lam, 2004).

Foundation degrees are new two-year qualifications (HEFCE[26], 2000a) which combine both 'academic' and 'vocational' learning (HEFCE, 2000b). These newly introduced qualifications first emerged in the U.K. (HEFCE, 2000a) in response to governments' policy of engaging the higher education sector to collaborate closely with businesses in order to: 1) assist workforce advancement, and development (Foskett, 2003), 2) meet

[26] HEFCE= Higher Education Funding Council for England

employers' needs (HEFCE, 2000a), and 3) make up for the shortage in the number of employees operating as senior technicians and associate professionals (DFES[27], 2003).

Work placements have become an essential complementary component in many higher education courses all over the world (Bullock, Gould, Hejmadi, & Lock, 2009). Work placements prepare tertiary education students to function in the workplace and become job-ready upon graduation by meeting relevant industry and accreditation requirements (Anema & McCoy, 2009). The significance of work placements within higher education courses emerges from the significance of "learning by doing" in developing students' professional knowledge and competencies essential for their future professions (Chesser-Smyth, 2005; Skinner & Whyte, 2004). Through their placements, students: a) acquire generic skills, b) are exposed to related real-life contexts, where they integrate theoretical knowledge with practice, c) are equipped with practical experience explicit to their workplace, and 4) enrich their curriculum vitae and hence improve their chances of employability upon graduation (Cross et al., 2006; Skinner & Whyte, 2004; Kissman & Van Tran, 1990; Vayda & Bogo, 1991). Examples of higher education courses which incorporate work placements within their curriculum include:

- Teaching qualifications, where placements often occur as part of school-university partnerships (Slater, 2010; Tsui, 2008),
- Nursing education, where placements often occur as part of partnerships between universities and relevant healthcare organisations (Lambert & Glacken, 2005), and
- Social care education, where placements often occur as part of formal links between universities and social care agencies (Skinner & Whyte, 2004).

Partnerships are considered to be at the core of work-based learning, and partnership as a notion operates in a variety of ways (Savin-Baden, 2003):

[27] DFES= Department for Children, Schools and Families

- The first form of partnership exists between higher education institutions and the funders of work-based learning, and

- The second form of partnership occurs between the university and the learner.

Whilst the learner remains the ‘main stakeholder in a tripartite partnership’ between university, employer, and student, s/he is left to ‘manage the complexity of being perceived by the university as a learner and by the employer as an employee’ (Savin-Baden, 2003:17).

2.2.5.3.2- Workplace Learning

Workplace learning is simply ‘learning through work’ (Reeve & Gallacher, 1999:1). It is an ‘informal setting’ allowing optimum practical exposure and ‘acquisition of robust and transferable skills’ (Billett, 1993:4). Learning and working are ‘interdependent’:

> *Learning and working are interdependent. We learn constantly through engaging in conscious goal-directed everyday activities- indeed, as we think and act, we learn* Billet (2001:21).

Learning through observation or mentoring is a social process of learning emphasised within workplace learning settings (Tsui, 2008). Observational learning is ‘learning that occurs as a function of observing, retaining, and... replicating novel behaviour executed by others’ (Western, Burton, & Kowalski, 2006:4). Wayne Weiten (2008) argues that there are four key processes of observational learning: attention, retention, reproduction, and motivation. Learning through observation starts with paying attention to another person’s behaviour and its consequences, moves to storing a mental representation of what had been observed, and concludes with reproducing the stored mental images into overt behaviour. All of these three steps are unlikely to successfully take place without motivation (Weiten, 2008). Mentoring in the workplace contributes in the formation of an identity of belonging to the related community of practice through the social interaction between the novice practitioners (mentees) and the more experienced practitioners (mentors) (Tsui,2008).

Workplace learning rests on the foundations of ‘learning as participation’ (Billet, 2001; Eraut, 2000; Fuller & Unwin, 2003) which challenge conventional ways of viewing ‘learning as acquisition’ (Beckett & Hager, 2002). Workplace learning takes ‘experience as the starting point for learning’ and has the potential to erode traditional boundaries: between knowledge and skills, between vocational and academic learning, and within disciplines themselves (Reeve & Gallacher, 1999:4).

The assumption that learning outside the framework of conventional education models is inferior, weak and concrete has stereotyped workplace learning for long (Billet, 2001). In reality, workplace learning has long existed before vocational colleges and universities had been established. Craft workers has long been applying their vocational knowledge in various fields such as building (castles, mansions, temples, etc) and manufacturing (soap, coal, cloths, etc) (Keller & Keller 1993; Whalley & Barley 1997), and transferring such knowledge across the generations (Billet, 2001). Moreover, many students experience difficulties and frustrations when attempting to apply acquired knowledge to workplace tasks (Raizen, 1994). This transferability problem can be attributed to the belief that knowledge acquired within a university context may not harmonize with knowledge required to solve specific tasks within a workplace context (Billet, 2001). Hence one of the aims of workplace learning is to ‘vocationalise’ higher education, attempting to minimise the problem of knowledge transferability (Reeve & Gallacher, 1999).

Workplace learning relocates learning from the education institution to the workplace and by doing so it not only emphasises experiential knowledge, but also emphasises theoretical knowledge (Walker & Dewar, 1997). Theoretical knowledge underpins practical application, although practitioners are often ‘unaware of the nature or extent of their learning’ (Beckett & Hager, 2002:119). They might come across theoretical knowledge, but they might not recognise it, because their learning is informal and implicit in contrast to the explicitness of formal education (Beckett & Hager, 2002).

The importance of informal learning in workplaces is not meant to override that of formal learning in education institutions (Billet, 2001). It is the 'well supported mixtures of formal and informal learning' which contribute to the development of proficient and productive practitioners (Beckett & Hager, 2002: 191).

Workplace learning is often 'informal'; however, there exists a formal format of learning in the workplace, often referred to as 'work-based learning' (Beckett and Hager, 2002). In work-based learning, employees, often sponsored by their employers, commence/continue studying in a work-related field of knowledge under the joint supervision of representatives from both the student's employer and education institution (Walker & Dewar, 1997). In this format of learning, the student's work becomes the main basis of the curriculum (Boud & Solomon 2001).

In summary, workplace learning is an 'organic' form of learning which acknowledges lifelong learning (Beckett & Hager, 2002). It also offers experiences which are explicit to the workplace context: experiences which are non-replicable within academic contexts (Billet, 2001). Through workplace learning, practitioners learn how to apply various forms of knowledge and competencies in harmony with one another, and learn how to 'put it all together', in order to achieve proficient practice in their occupations (Beckett & Hager, 2002). The contributions of the workplace to learning are neither 'incidental' nor 'ad hoc'; in contrast, they are 'rich, complex and probably difficult to avoid' (Billet, 2001:39). However, despite all the prominence it has gained, workplace learning initiatives have been, and continue to be, 'topics without a settled home' (Beckett & Hager, 2002:100).

2.2.6- Decision-Making about Curricular and Pedagogical Approaches from a Social Science Perspective

The two previous subsections (2.2.4 and 2.2.5) examined the different curricular approaches and pedagogical strategies that may be adopted in the education of a tertiary program/course. This subsection examines decision making about the curricular approach and pedagogical strategy to be adopted in a field of study: what to include/ what to not include in a curriculum, how to organise content, and how to deliver such content. Decision making about curriculum and pedagogy is examined through Bernstein's perspective: the notion of social power and control.

In volume 3 of his book "Class, Codes, and Control: Towards a Theory of Educational Transmissions" Bernstein introduced two terms: 'classification' and 'framing' (1977). According to Bernstein, classification refers to 'the degree of boundary maintenance between contents' in a curriculum, and framing refers to 'the form of the context in which knowledge is transmitted and received' (p.88). He then argued that decisions on the curriculum, pedagogy, and evaluation of any discipline are decisions on the classification and framing of the educational knowledge code relating to that discipline. These decisions reflect both the 'distribution of power and the principles of social control' (p. 85). In his more recent publication: "Pedagogy, Symbolic Control and Identity", Bernstein re-explores his notion by arguing that the manner through which the code of a certain discipline is classified and framed reflects and translates the interests of the social groups that are the stakeholders of such a discipline (2000).

Power relations 'create, legitimatise, or reproduce boundaries between different categories of discourses' (Bernstein, 2000:12). In this respect, Bernstein (2000) gives the example of the categories of discourse in a secondary school or university, where the classification and the framing between these discourse categories are a reflection of the social division which exists between labour of discourse:

> *We have shown how power relations translate into principles of strong and weak classifications and how these principles establish social divisions of labour, how these principles establish identities, how these principles establish voices* (p.12).

Bernstein argues that the classification and framing of content contribute to each discourse category developing its unique identity, an 'identity with its own internal rules and special voice' (2000:6). However, in cases of weak classification, categories have less specialised voices and are in danger of losing their identities (Bernstein, 2000). Bernstein argues that the emergence of new fields of knowledge comes as a consequence of weak classification in more conventional fields of knowledge. For example, 'regionalised' fields of knowledge (e.g. information system, biochemistry, biophysics, etc) emerge as a result of weak classification of the more centralised fields of knowledge (e.g. maths, physics, chemistry, biology, etc) (2000:9). In this respect, forensic science may be perceived as one of these regionalised fields of knowledge which is striving to emerge as a stand-alone field of knowledge amongst the more centralised fields of knowledge which comprise it.

Based on his theory of power, control, and social groups, Bernstein inquired into the existence of any general principles which underlie the 'transformation of knowledge into pedagogic communication' (2000:25). The result of his inquiry was the emergence of the notion of the "pedagogic device" (Bernstein, 2000; Singh, 2002). The pedagogic device operates in accordance with certain rules which are hierarchically interrelated (Singh, 2002). These rules are (Bernstein, 2000: 28-37):

- *Distributive Rules*: regulate the relationships between power, social groups, forms of consciousness, and practice in terms of who may transmit what to whom and under what conditions. This is the phase of knowledge production.

- *Recontexualising Rules (Pedagogic Discourse)*: embed two discourses: *instructional discourse* (discourse of curricular content) and *regulative discourse* (discourse of social order which regulates order, relation, and identity). The instructional discourse is embedded in the regulative discourse, where the regulative discourse is the dominant one. Pedagogic discourse is the phase of knowledge recontexualising.

- *Evaluative Rules*: constitute specific pedagogic practices by recognising what count as valid realisations of instructional texts and regulative texts. This is the phase of knowledge acquisition.

Through Bernstein's pedagogic device specialised knowledge is recontexualised and reconceptualised where it is transformed from its original site to a new site where it is related to other discourses and then acquired (Singh, 2002). Bernstein's pedagogic device provides researchers and educators with 'explicit criteria/rules to describe the macro and micro structuring of knowledge and in particular the generative relations of power and control constituting knowledge' (Singh, 2002:571). Bernstein's pedagogic device will be adopted by the research to promote discourse amongst identified conceptions.

2.2.7- The role of Higher Education in Promoting Discipline-Specific Skills, Generic Skills, and Graduate Attributes.

Higher education courses need to emphasise discipline-specific skills, generic skills, and graduate attributes (Barrie, 2005; Fallows & Steven, 2000). The discipline-specific skills refer to the knowledge and skills which are pertinent to conduct and complete activities and tasks related to a particular occupation/profession (Barrie, 2005). Generic skills are general capabilities which are transferable and useful in any work situation (e.g. teamwork, communication skills, planning and organising, problem solving skills, critical thinking, and life-long learning (Bowden & Marton, 1998). Graduate attributes have been described by Bowden, Hart, King, Trigwell and Watts as:

> *The qualities, skills, and understandings a university community agrees its students should develop during their time with the institution. These attributes include but go beyond the disciplinary expertise or technical knowledge that has traditionally formed the core of most university courses. They are qualities that also prepare graduates as agents of social good in an unknown future* (2000:3).

Out of the range of generic skills which are expected to be acquired by graduates of higher education courses, the literature focuses mainly on critical thinking, communications skills, and problem solving skills which might be of more significance to the forensic science profession.

Critical thinking comprises one of the important generic skills- if not the most important at all- for a number of disciplines and professions (Assister, 1995; Beyer, 1987). The definition of critical thinking is usually approached in terms of a skill component and an attitude component (Garside, 1996). Critical thinking is defined as 'the propensity and skill to engage in an activity with reflective scepticism' (McPeck, 1981:8). Four defining features of critical thinking have been suggested: (a) clear, precise, accurate, relevant, logical, and consistent thinking; (b) a controlled sense of scepticism or disbelief about claims, assertions, and conclusions; (c) taking stock of existing information and identifying holes and weaknesses; and (d) freedom from bias and prejudice (Garside, 1996).

Within the same context, Beyer (1985) identified 10 specific critical thinking skills: (1) distinguishing between verifiable facts and value claims, (2) determining the reliability of a source, (3) determining the factual accuracy of a statement, (4) distinguishing relevant from irrelevant information, (5) detecting bias, (6) identified unstated assumptions, (7) identifying ambiguous or equivocal claims or arguments, (8) recognising logical inconsistencies or fallacies in a line of reasoning, (9) distinguishing between warranted and unwarranted claims, and (10) determining the strength of an argument.

Garside argued that 'critical thinking involves a set of skills that are most effectively taught within the context of a subject area. Since it is impossible to think critically about something of which one knows nothing, critical thinking is dependent on a sufficient base of knowledge' (Garside, 1996:215). In this context, Beckett and Hager argue that PBL is one of the most efficient pedagogical strategies for promoting critical thinking, because it promotes the "know how" forms of knowledge (2002). Through such promotion, PBL emphasises active student participation, meaningful interaction, and opportunities for students to challenge and question which are all skills underpinning critical thinking (Garside, 1996). Complementing Beckett and Hager, Savin-Baden argues that part of the success and popularity of PBL is that it promotes "criticality" in students by providing them with opportunities to 'challenge borders, construct knowledge and to evaluate critically both personal knowledge and propositional knowledge on their own terms' (2003:23).

On the other hand, critical thinking is also influenced and promoted by non-academic activities and experiences (Elander et al., 2006). For example, Terenzini et al. (1995) found that both instructional and out of class experiences made unique contributions to gains in critical thinking, over and above pre-college levels of critical thinking and other characteristics.

Effective communication is one of the essential generic skills sought after by employers (National Board of Employment, Education and Training, 1992). Communication skills comprise the ability to communicate ideas and information effectively:

- ‘to a range of audiences’
- ‘for a range of purposes’
- ‘in various situations’
- ‘by suitable means’ such as written language, oral language, digital presentations, body language, etc (Aspire Training and Consulting, 2003:11).

Problem-solving is a complex skill which requires a range of capabilities and abilities (Warner, 2000). Problem-solving requires the ability to:

- Identify the problem
- Clarify the problem
- Apply problem-solving strategies
- Develop practical and/or innovative solutions
- Implement the solutions
- Evaluate the outcome,
- Work independently or in a team to solve problems (Aspire Training and Consulting, 2003:12).

Regardless of the curricular and pedagogical approach adopted in a higher education course/program, any approach needs to emphasise discipline specific skills, generic skills, and general graduate capabilities (Assister, 1995; Elander, Harrington, Norton, Robinson, & Reddy, 2006).

The first body of literature concludes after examining literature about higher education and science education, considering medical education as a comparative case study to forensic science education, and exploring the various curricular and pedagogical models in education and decision-making in regard to these models. The first body of literature comprised the education landscape for the research. The second body of literature will comprise the forensic science education landscape for the research. These two landscapes will interconnect to inform the research analyses and findings.

2.3- The Forensic Science Education Body of Literature

Forensic science education comprises the second body of literature. This body of literature comprises two subsections. The first subsection examines forensic science from a higher education perspective. The second subsection explores the epistemological relation between knowledge, practice, and identity in forensic science. Such a relation supports the notion of approaching forensic science education through its determining factors: forensic science knowledge, forensic science practice, and forensic science identity. Each of these factors is examined in an individual section within the second subsection.

2.3.1- Forensic Science in Higher Education

Over the last two decades, forensic science education has expanded to offer more comprehensive forensic science programs (Burns, 2006). This expansion came as a response to the increased reliance of the criminal justice system on the forensic laboratories' services (Quarino and Brettell, 2009) and the increased public interest in forensic science (Smallwood, 2002; Houck, 2006; Mennell, 2006).

In the U.S.A., the American Academy of Forensic Sciences (AAFS) website reveals over 155 undergraduate forensic science programs, nearly 70% of which lead to bachelor's degrees in forensic science or in forensic science associated with other disciplines such as chemistry, biology, criminal justice, anthropology, and/or psychology (AAFS, Electronic[28]). The non-award programs (~ 30%) distribute between associate degrees, certificate programs, and training programs mainly in forensic DNA profiling. The AAFS website also reveals over 55 graduate programs in forensic science within the U.S.A. Nearly all of these graduate programs lead to a Master's degree.

In the U.K., forensic science education is not any less popular. The number of students studying forensic science degrees increased from 2,191 in 2002-03 to 5,664 in 2007-08 (Skills for Justice, 2009). Currently, there are over 500 listed combinations of undergraduate courses with 'forensic' in the title being offered by over 70 British universities (Daéid & Roux, 2010).

In Australia, the number of education institutions which offer forensic science to the public has boomed from 1 university in 1994 to nearly 20 universities in 2005 (Lewis et al., 2005). At present, the National Institute of Forensic Science website reports 23 universities which offer forensic qualifications at all levels in Australia, from certificates to postgraduate degrees (NIFS, Electronic[29]).

The rapid growth in forensic science education has raised concerns about the quality of many of the offered forensic science programs (Quarino & Brettell, 2009). This rapid growth is argued to be the cause of the inconsistencies and the lack of clarity reflected in the huge range of forensic science courses on offer (Lewis et al., 2005). Such inconsistency in education has resulted in lack of agreement on the competencies acquired by forensic science graduates which have led to criticisms from potential employers (Lewis et al., 2005). This randomness in forensic science education has pushed some countries to set up reviews to study the current status of this education and establish some recommendations for the future (Daéid & Roux, 2010). In this respect, the following three studies have significance:

[28] http://aafs.org/colleges-universities, Accessed: 01/08/10

[29] http://www.nifs.com.au/F_S_A/FSA_frame.html?Courses.asp&1, Accessed: 02/08/10

a) In the U.S.A., The National Institute of Justice (NIJ) sponsored a working group to serve as a Technical Working Group For Education and Training (TWGED) in forensic science. TWGED's role was to develop consensus guidelines for academic programs in forensic science (Almirall & Furton, 2003). Following the work of this group, NIJ published a report in 2004. This report has set up academic guidelines for both undergraduate and postgraduate forensic science programs offered by American universities. This report has advanced many recommendations in relation to how curricula can best be structured and organised to endorse quality education which responds to specific industry needs. The report recommended that the curricula of forensic science courses incorporate a solid science component with extensive laboratory-work that set up an adequate groundwork for a forensic science career (NIJ, 2004). As a consequence of this report a Forensic Science Educational Program Accreditation Commission (FEPAC) was established (Quarino & Brettell, 2009). The FEPAC role is to accredit forensic science academic programs, where applying for accreditation is **entirely voluntary** to the education institute offering a forensic science program or course. As of December 2008, the majority of the forensic science programs in the U.S.A. are still not accredited. Only 19 forensic science programs enjoy accreditation by the FEPAC (Quarino & Brettell, 2009).

b) In the U.K., the Sector Skills Council for Science, Engineering and Manufacturing conducted a study on forensic science and published a report in 2004 which recommended that: 1) forensic science degree content be monitored for quality assurance and be set up in close cooperation with the forensic industry; 2) highly professional technical/ laboratory skills training programs be established; 3) pure science disciplines (e.g. chemistry) in higher education receive more government funding. (SEMTA, 2004). This study was supplemented by a recent study in 2009 conducted by Skills for Justice in response to the continuous debate and concerns of the British government about the "value" of many of the forensic science courses offered within the U.K. (Daéid & Roux, 2010). The Skills for Justice's report noted that a number of the issues raised in SEMTA's 2004 report remain a current concern including the failure of large number of forensic science graduates to meet employers' expectations and requirements (Skills for Justice, 2009). The report highlighted a number of recommendations focused on the strengthening and the formalising of links, agreements, and partnerships between higher education providers, forensic science employers, and forensic science associations to promote quality and ensure relevance of forensic science courses. The study also recommended that further research be conducted in the area of forensic science education (Skills for Justice, 2009).

c) In Australia, NIFS conducted a study in 2005, in which 463 forensic science practitioners across various states and in various departments and specialisations had been surveyed in relation to a number of issues including their academic qualifications. The results of this survey were as follows (NIFS, 2006):

- 28 (6.05%) practitioners have entered the field after year 10
- 91 (19.65%) practitioners have entered the field after year 12
- 63(13.61%) practitioners have achieved TAFE qualifications prior to entering the field.
- 282 (60.69%) practitioners have achieved a university degree prior to entering the field

As for qualifications obtained after joining the forensic science field, the number of practitioners that achieved a TAFE qualification is 1.4 times greater than those who achieved a university qualification.

At the end of the study NIFS (2006: 2-3) proposed a number of recommendations, some of which are: 1) the adoption of a 'consistent approach to forensic practitioner training and education' in terms of both the qualifications required as a prerequisite for entry level into forensic practice and 'structured program of induction and on-going training'; 2) revision of forensic programs and resources within Australasia and worldwide in terms of training, education, and accreditation; 3) closer cooperation between the forensic industry and forensic science educational providers. Some of the recommendations established in this report matched those that were published in the 2004 American and British reports.

Typically, crime scene investigation has been explicitly performed by sworn police officers whose training was largely informal with an apprentice type system of on the job training using a buddy system (Horswell, 2004). The need for formal education and training emerged as a result of the weaknesses in both the understanding of scientific concepts and the use of scientific methodology demonstrated by forensic science practitioners in the late 1980s (Wood, 1997). This pushed a number of countries (e.g. Australia, Canada, U.K., and U.S.A.) to encourage independent tertiary providers to develop diploma degrees in forensic investigation to educate forensic practitioners especially field practitioners who often lack science knowledge (Horswell, 2004). For example, in Australia, all police jurisdictions cooperated in the development of a national curriculum for a diploma in forensic science investigation (Australian National Training Authority, 1995). The project began with the development of a profile that defined the role of investigators in each speciality and identified the competencies and underpinning knowledge and skills that were required (Brightman & Wardrop, 1993). Curricula for five specialisations were developed: crime scene investigation, fingerprint identification, document examination, fire and explosion scene investigation, and firearms and toolmarks identification (Horswell, 2004).

Approximately 50% of the forensic programmes consisted of foundation knowledge and skills in (Horswell, 2004):

- sciences (mathematics, statistics chemistry, physics, biology, human anatomy, and physiology),
- computing,
- communications, and
- discipline-specific component for crime scene specialisation (crime scene investigation and management, forensic photography, physical evidence, etc).

The aim of these diploma programmes included the provision of graduates with the necessary knowledge, technical skills, and attitudes to effectively manage and investigate a crime scene and implement quality assurance measures. These programmes also aimed to develop a level of scientific awareness sufficient to enable them to communicate effectively with scientific or other experts, and present forensic evidence competently to courts of law (Australian National Training Authority, 1995).

Despite the recognised high quality of the national diploma programme, only the crime scene investigation and fingerprint identification specialisations have been implemented to date. Furthermore, despite in principle support from all Australian jurisdictions for the national forensic diploma programme, it was only officially adopted by the Australian Federal Police, the New South Wales and Victoria Police, with other jurisdictions (Western Australia and South Australia Police) adopting a certificate level programme which did not incorporate science and maths components (Horswell, 2004).

Today, there is a growing trend towards both university-based recruit education and 'civilianization' of forensic investigation (Horswell, 2004). In this respect, recommendations made by Senior Managers of Australian and New Zealand Forensic Laboratories (SMANZFL), in a recent review of forensic education and training in Australia, stressed the necessity to raise the level of qualification required for police forensic staff to degree level by the year 2010 (NIFS, 2006). In response to these recommendations, the Forensic Course Team at Curtin University of Technology and Western Australia Police initiated the development of a co-delivered program leading to the award of a BSc in forensic investigation (Lewis, Wells, Tucker, & Kelly, 2008). This new police-university co-delivered undergraduate course aimed to give forensic police officers who had already taken some sort of education following year 12 (a diploma or a certificate) the opportunity to have a formal part-time tertiary degree which would back up their expertise with scientific knowledge and competencies in addition to their specific area of expertise (Lewis et al., 2008).

The key qualifications, which have been of 'relevance to the forensic community to date, are the diploma and bachelor degrees' (NIFS, 2006:17). However, some departments require that their laboratory managers, supervisors and technical leaders continue further study and acquire postgraduate education (Graduate Diploma, MSc or even PhD degrees) relevant to their positions (Gaensslen, 2003).

The introduction of forensic science education in academia remains a topic of debate amongst forensic science practitioners and educators (Quarino & Brettell, 2009). Such introduction is argued to possess a number of advantages:

- The opportunity to employ graduates with strong scientific backgrounds who 'possess most, if not all, of the necessary underpinning knowledge and skills in science, maths, and computing' (Horswell, 2004: 61). This would reduce long in-house training periods where recruits need to 'only focus on their forensic applications and on jurisdiction-specific processes and procedures'. This saves both financial and human resources which are often wasted on trying to back up forensic practitioners with fundamental and basic science components (Horswell, 2004: 61).

- The increase in the number of forensic practitioners with academic backgrounds in forensic science. This would create a 'workforce with a stake in the profession', where professionals are more inclined to view 'forensic employment as a career rather than simply as a job' (Quarino & Brettel, 2009:1991).

- The development and promotion of forensic science through partnering with forensic science centres through research projects (Sensabaugh, 1998). Such partnerships will promote forensic science practice to become a part of science and science research (Kobus & Liddy, 2008).

- The encouragement of forensic practitioners, who graduated from forensic science programs, to actively engage in forensic science research, rather than leaving this task to be predominantly conducted by academics and medical specialists (Quarino & Brettel, 2009).

Despite the emphasised advantages, a number of disadvantages have been asserted against forensic science tertiary education:

- A number of the academic forensic science programs, which rely solely on the prominence forensic science has gained, lack genuine partnerships with the industry. Graduates of such programs often lack essential forensic competencies and are often unemployable in the forensic science field (Kobus & Liddy, 2008).

- Forensic science education has sometimes been used by universities explicitly for business reasons, where the word ‘forensic’ is used as a popular adjective to attract enrolments and polish the less attractive conventional science courses (e.g. chemistry) which are subject to closure (SEMTA, 2004).

In Australia, forensic science programs have been highly successful in attracting quality students with high entry scores. However, a recent study conducted by Kobus and Liddy (2008) reported a downturn in students’ enrolments and a corresponding drop in entry scores for forensic science in Australia. This downturn and drop were attributed to two main reasons: a) students’ expectations are not being met and b) employment opportunities are limited in the main stream of forensic science in Australia compared to the large number of students graduating each year from forensic science programs (Kobus & Liddy, 2008). Kobus and Liddy argue that forensic science programs which do not have genuine partnerships with the industry will have a limited life because such programs do not possess credibility, practice based learning experiences, and career opportunities for their graduates (2008). Simon Lewis argues that a major concern about any forensic science course is whether or not such a course creates an “authentic learning experience” by: a) developing students’ essential skills to function as expert witnesses (Belardi, 2009) and b) connecting with local forensic science service providers (Lewis et al., 2005).

In the first body of literature, medical education was introduced as a comparative case study to forensic science education. Whilst forensic science and medicine are similar in some aspects, they are different in many other ones. Medicine possesses a defined body of knowledge and specialisations. Medicine also has distinctive practical features. Finally, medicine enjoys a defined academic stature. Forensic science is a field which is unclear and uncertain about the nature of its knowledge and practice. Moreover, forensic science education does not enjoy a defined academic stature similar to that of medical education.

The next subsection introduces literature which supports the epistemological relation between knowledge, practice, and identity. Such a literature backs up the notion of approaching forensic science education through its determining factors: forensic science knowledge, forensic science practice, and forensic science identity.

2.3.2- The Determining Factors of Forensic Science Education: Knowledge, Practice, and Identity

Throughout the literature, many scholars have approached either directly or indirectly the epistemological relationship between knowledge and practice in reflecting personal identities, academic identities, professional identities and social identities (Barnet, 2000; Wenger, 1998; Barnett, Parry & Coate, 2001). Such epistemological conceptions are closely connected to ontological conceptions to an extent where it becomes difficult to consider one without the other (Allison & Pomeroy, 2000).

Knowledge exists in 2 broad forms (Halloun, 2006: 9-12):

- *Experiential knowledge which is the result of a direct transaction/interaction between the knower and the object of study including the surrounding environment. Experiential knowledge can be either subjective or objective. In this respect, scientific knowledge can be defined as the most objective form of experiential knowledge about physical realities.*

- *Traded knowledge which is the result of interaction with other people and/or with public knowledge and social realities.*

Knowledge may be acquired through various ways (Graziano & Raulin, 1993:10-13):

- Tenacity: Acquiring knowledge through ‘accepting ideas as valid because they have been accepted for so long or repeated so often that they seem true’.
- Intuition: Knowledge acquisition through ‘accepting ideas as valid because they “feel” intuitively true’.
- Authority: Acquiring knowledge through ‘accepting ideas as valid because some respected authority asserts that the ideas are true’.
- Rationalism: Knowledge acquisition through reasoning, where valid ideas are developed using ‘existing ideas and principles of logic’.
- Empiricism: Gaining knowledge through observation; i.e., through experiencing it via the human senses.
- Science: Acquiring knowledge through a ‘process that combines the principles of rationalism with the process of empiricism’, using the first to develop theories and the second to test such theories.

Halloun (2006) argues that human knowledge about physical realities is a mixture of both experiential (practical) and traded knowledge. Similarly, Carr and Kemmis (1986:190) connect knowledge and practice arguing that ‘personal knowledge develops in and through practice’. On the same topic, Garrick relates knowledge to practice by claiming that ‘to know is to be able to perform one’s knowledge, with knowledge being linked directly to performance on a task’ (1998:101).

A growing number of studies on subject cultures and disciplinary identities have revealed the power of knowledge fields and their consequent practical applications in shaping academic life (Huber, 1990; Gerholm, 1990; Becher, 1989; Henkel 2000). Barnett, Parry and Coate (2001:436) assert that knowledge fields in their epistemology, structure, value and practice dominate higher education as both sources of academic identities and means of curriculum structuring. Moreover, according to Wenger

(1998:215), learning itself is an experience of identity because it ‘transforms who we are and what we can do’.

For Barnet, courses’ identities, reflected in curriculum organisation and forms of delivery, are shaped by both the nature of the knowledge fields incorporated and the nature of practice settings where such knowledge fields are applied (2000). Vos, De Vos & Reiding (1999) argue that for a new subject to survive, it must develop a clear identity that provides it with coherent aims, content, and pedagogies and makes it distinguishable among students and teachers from other traditional disciplines. Within this context, Bernstein (1977: 96) argues that emerging interdisciplinary courses (e.g. biophysics, biochemistry, psycho-linguistics, etc) are ‘permitted to develop’ only ‘after long socialization into subject loyalty’. Bernstein adds that ‘in order to change an identity, a previous one has to be weakened and a new one created’ (1977: 96).As an example, Bernstein argues that biochemistry developed only after long socialisation between biology and chemistry. Such long socialisation between these two fields of knowledge and their practical applications contributed to the creation of a new disciplinary identity (biochemistry).

These extensive arguments by scholars about the epistemological and ontological relationships between knowledge, practice, and identity give rise to a standpoint that the education of a discipline may best be researched through investigating the nature of knowledge, practice, and identity of such a discipline. Adopting this standpoint, the research will examine in the following subsections the literature concerned with the determining factors of forensic science education: forensic science knowledge, practice, and identity.

2.3.2.1- Forensic Science Knowledge

The forensic science knowledge base is mainly based on the inclusion of scientific concepts, principles, and theories (Caddy, 2000). It firmly rests on a foundation of the basic scientific principles of physics, chemistry, and biology (Rudin & Inman, 2001). In this respect, Caddy (2000) argues that science knowledge is required at:

- Basic to moderate levels to assist in problem solving of forensic field tasks which rely to a greater extent on the proper understanding of the general concepts of science and mathematics.

- Advanced levels to assist in the analysis tasks of the laboratory which require an in-depth understanding of science and mathematics.

In addition to science knowledge, forensics also rests on a foundation of three explicit forensic principles (Inman & Rudin, 2001; Horswell, 2004; Broeders, 2006):

i. **'Locard's Exchange Principle'** formulated in 1910 and which is based on the claim that 'every contact leaves a trace'. Locard's Principle has established the ontological foundation of forensic science and has been supported by other forensic pioneers such as Kirk (1974:2) who stated the following:

> *Wherever he steps, whatever he touches, whatever he leaves even unconsciously- will serve as silent evidence against him. Not only his fingerprints and his shoeprints, but also his hair, the fibres from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects- all these and more bear mute witness against him.*

ii. **'The principle of uniqueness'** which is an unproved assumption adopted by forensic practitioners based on the belief that 'nature never repeats itself'.

iii. **'The principle of individualisation'** which claims that every print, trace, or impression can be related to a unique source. In this respect, Kirk (1963) asserted that criminalistics is simply the science of individualisation.

It is the second and the third features of forensic knowledge which create scepticism and debate about the scientific identity of forensic inquiry. These debates will be addressed and detailed later in the forensic science identity section.

The components of forensic science courses offered worldwide may vary from courses with heavy science content (e.g. chemistry and biology) and light forensic science emphasis, to courses with heavy forensic science content (e.g. fingerprinting, crime scene examination, and physical evidence analysis) and light science emphasis. However, some scholars argue that the science component within a forensic science course should not be compromised, because it is easier to teach a chemist or a biologist how to identify, collect, preserve, and analyse physical evidence, rather than it is to teach an investigator the methods and laboratory applications of chemistry or biology (Engber, 2005). Another key issue forensic science courses/programs should emphasise is how to communicate forensic methods and findings to a variety of audiences, most importantly to juries in a trial, because the value of any forensic evidence and any findings might be lost if not properly communicated to a court of law (McCormack, 2005).

In addition to the courses and programs run by academic institutions and which are offered to the general public, professional forensic organisations and bodies (e.g. American College of Forensic Examiners and National Institute of Forensic Science) continuously run programs and courses that are specifically designed for legitimate professionals to provide them with the knowledge that will develop and update their information, enabling them to function with confidence in court (Cavallo, 2006).

2.3.2.2- Forensic Science Practice

Forensic practitioners are mainly categorised between (Horswell, 2004):

- field practitioners: personnel mainly required to process the crime scene:

examine, photograph, identify, and collect any potential evidence; and

- laboratory practitioners: personnel mainly required to test and analyse collected evidence from crime scenes.

Forensic practice is based on two major premises (Horswell, 2004):

i. The evidence left at the crime scene or removed from the crime scene results from a contact by an individual or individuals (Locard's Exchange Principle).
ii. The collected evidence would lead to the identification of the individual who left the evidence based on the assumptions that such evidence is unique (principle of uniqueness) and hence can be related to a unique source (principle of individualisation).

Any person involved in crime scene examination has a duty not only to record the obvious, but also to look beyond that and take notice of what the evidence may indicate in relation to the whole crime scenario (White, 2004). Conventionally, forensic science practitioners perceive their practice as comprising five phases (Horswell, 2004):

1. **Transfer-** The exchange of material between two objects; such an exchange result in the creation of evidence (Locard, 1928; 1930).
2. **Identification-** Defining the physiochemical nature of the evidence (Saferstein, 1988).
3. **Classification/ Individualisation-** Attempting to determine the source of the evidence (Kirk, 1963; DeForest, Lee & Gaensslen, 1983).
4. **Association-** Linking a person (source of evidence) to a crime scene (Osterburg, 1968).
5. **Reconstruction-** Understanding the sequence of past events (Deforest et al.,1983).

Forensic science requires 'practice, continuing education, and multidisciplinary interactions', where efficient learning starts in the classroom with foundation knowledge and develops into real life situations where 'knowledge can be tested and honed to usefulness' (Burns, 2006:11). These situations often incorporate complex problems that may be hard to solve and questions that may be difficult to answer, unlike the classroom environment where there is an answer for every question and a solution for every problem (Cavallo, 2006). For instance, the skills of crime scene investigation emerge from years of experience and exposure to 'the variety of offences and ways of committing offences, which is complemented by education and training, not the other way round' (Horswell, 2004:42).

Forensic science specialisations are as diverse as the disciplines which fall within the forensic science landscape. The majority of these specialisations can be grouped into five categories:

a. Crime Scene Investigation

The majority of crime scene investigators are sworn police officers who have been trained to document crime scenes and evidence, and then collect, package, and send evidence to laboratories; i.e. they are field workers (Gaensslen, 2003). The training pathways in crime scene investigation may be relatively short and informal. However, in more recent years there have been calls for crime scene investigators to have formal education (Gaensslen, 2003). These calls primarily emerged because of the belief that the proper processing of a crime scene is the 'lynchpin' of successful forensic investigations (Horswell, 2004). Regardless of how rigorous later laboratory analyses are, such analyses are worthless if the evidence collected at the scene does not include samples of sufficient size, if control and reference samples are not taken, or if the packaging, labelling, and storage are inappropriate (NIJ, 1999; Horswell, 2004).

b. Criminalistics- Technical

Criminalistics-Technical mainly covers fingerprinting, document examination, firearms, and tool mark identification (Gaensslen, 2003). Practitioners in these fields may or may not hold tertiary qualifications. However, they are required to undergo intensive training before they become qualified for casework (Gaensslen, 2003). Duration of training varies from one speciality to another, the lengthiest of which is document examination (Gaensslen, 2003).

c. Criminalistics-Scientific

Criminalistics- Scientific mainly covers forensic chemistry, forensic biology, botany, and microscopy, Hence, practitioners of this category are forensic laboratory practitioners who work on the evidence collected by crime scene investigators (Gaensslen, 2003). Currently, a BSc is a minimum requirement for admission to any of the criminalistics-scientific specialities (Gaensslen, 2003). Research has repeatedly indicated that laboratory directories have a preference for applicants with BSc degrees in chemistry/biochemistry, followed by biology and then forensic science with heavy chemistry and natural science components (Almirall and Furton, 2003).

d. Forensic Biomedical Specialisations

These specialisations cover forensic pathology, odontology, toxicology, entomology, and psychiatry (Gaensslen, 2003). To become a forensic specialist in those areas, individuals should primarily be accredited as practitioners in their respective fields followed by intensive training to be certified as forensic experts in this same field. For example, to become a forensic odontologist, an individual must qualify as a dentist first, and then undergo intensive training and education to be certified as a forensic odontologist (Gaensslen, 2003).

e. Other Forensic Specialisations

These specialisations cover mainly forensic engineering, computing, and psychology, where individuals should first qualify as practitioners in their fields (engineer, computer scientist, and psychologist) before undergoing intensive training to qualify as forensic specialists in those fields (Gaensslen, 2003).

The lack of scientific education for many crime scene investigators and technical criminalistics has been a source of concern and complaint.

The audience of non-scientifically oriented police officers and detectives are

> *virtually always the first to arrive at a scene. More often than not, a law enforcement officer or evidence collection technician with minimal scientific training is the person tasked with the all-important charge of recognizing and collecting evidence. Less and less often will a criminalist from the laboratory be called to the crime scene, and the decision to do so is usually that of those already there* (Inman & Rudin, 2001:62).

In this respect, Horswell argues that both laboratory and field practitioners should have equal status in a team which contributes to a holistic investigation and interpretation on an incident (2004). Equal status will be facilitated only if field practitioners have the knowledge, professional skills and attitudes equivalent to a degree qualification (Horswell, 2004). Crime scene investigation sometimes requires the attendance of field, laboratory, and medical practitioners who must be prepared to combine their personal knowledge and experiences with those of others (White, 2004). Field practitioners with a science degree level qualification are able to approach their work from a perspective of scientific inquiry and ethical judgement (Horswell, 2004). Hence, scientific and mathematical concepts are not only vital for laboratory practice, but also for field practice because problem solving in forensic investigation depends on the understanding of these concepts (Caddy, 2000).

In their every day work, carrying out normal and complex tasks, forensic scientists use a combination of 'explicit, codified standard operating procedures and tacit knowledge developed through their ongoing practice' (Doak & Assimakopoulos, 2006: 201). Professional performance of an expert involves sequences of routinised action interrupted by rapid intuitive decisions based on tacit understanding of the situation (Eraut, 2000). Expertise is based on past experiences where 'the expert seems to remember holistic images from earlier experiences, matches and compares them and finds through the perception of diffuse signals that something in this situation is different from the memorized ones' (Herbig et al., 2001:690). Therefore, what characterises forensic science experts from trainees and beginners within the profession is that experts are often able to act immediately on critical and complex tasks, unlike the novice who has to depend 'on time consuming sequential-analytical interpretation of information' (Herbig et al., 2001:690).

Tacit knowledge is created, shared, and exchanged within the *community of practice* of each particular field (Doak & Assimakopoulus, 2007). Novices in a particular field learn the art of practice, knowing how, by full engagement in a task, job, or profession (Brown & Duguid, 2001), much of which lies tacitly in the *community of practice* of that particular field (Duguid, 2005). Hence, beginners within the forensic science profession acquire know-how or tacit knowledge through engagement and participation in their community of practice (Doak & Assimakopoulus, 2007).

Newcomers in a field acquire tacit knowledge through a process termed as *legitimate peripheral participation* (Lave & Wenger, 1991). The legitimate peripheral participation theory is used to 'characterize the process by which newcomers become included in a community of practice' (Wenger, 1998:100). Newcomers gradually 'learn about the ongoing practice of the organisation', and hence each 'moves from a position on the periphery' (novice) to 'greater centrality' (experts) (Doak & Assimakopoulus, 2007:114-115). Once 'new-comers have moved on from the role of peripheral participants to the status of fully legitimate members of the community, the learning they have acquired, together with its pattern and implicit complex logic, becomes part of their tacit knowledge' (Gherardi, Nicolini, & Odella, 1998:291). Hence, forensic science newcomers, through gradual participation in their community of practice, learn from more 'experienced old-timers' the range of experiences, practices, and conduct in addition to the community's common language. Hence, the more these newcomers participate, the further they move from the periphery to the centre of forensic science practice (Doak & Assimakopoulus, 2007:114-115).

Another vital building block of forensic practice is the communication of evidence to a court of law (Davey, 2008; White, 2004). Regardless of how skilled, knowledgeable, and educated a forensic scientist may be, such expertise is of very little value if the expert concerned is unable to adequately communicate results both on paper and in the witness box (White, 2004).

Affiliation with professional bodies and organisations (e.g. American Academy of Forensic Science (AAFS), American College of Forensic Examiners (ACFEI), Australia and New Zealand Forensic Science Society (ANZFSS), etc) is vital for forensic science practitioners and educators (Cavallo, 2006; Klein, 2006; Tacy, 2006; De Francesco, 2006). Such affiliation provides these practitioners and educators with: 1) validity and credibility of their various forensic science professions (Tacy, 2006), 2) recognition within their respective fields as professionals (Cavallo, 2006) which primarily contributes in their professional identity (De Francesco, 2006), and 3) continuing training and education which maintain an up-to-date level of knowledge (Cavallo, 2006). It should be noted in this respect that 'pattern evidence' specialities (fingerprinting, questioned document examination, firearms examination, and tool marks examination) have their own certification bodies, professional organisations, and professional journals, independent from those of other forensic specialisations (Gaensslen, 2003:1153).

Despite the existence of common guidelines, internationally agreed standards, and common codes of conduct, forensic science is practiced differently in different jurisdictions across different countries and sometimes across different states of the same country (Horswell, 2004). The question whether or not forensic science is a "true profession" or is able to represent itself as a profession remains a topic of discussion and further inquiry (Robertson, 2010).

2.3.2.3- Forensic Science Identity

Since its inception, forensic science has 'evoked an air of mystery and intrigue' (Inman & Rudin, 2001:22). In an attempt to understand such ambiguity, this research approaches forensic science identity from various standpoints and perspectives: a) the "relational identity" of forensic science with law and the judicial system, b) the image from public's perceptions, c) the academic identity of forensic science, d) the science nature of forensic science, and e) the occupational identity of forensic science within the police arena.

A- Relational Identity between Forensic Science and Law

Over many years, forensic science has gained importance within the criminal justice arena (Jonakait, 1991). Forensic science evidence has always been valued by the judicial system as being more reliable than eyewitness identifications, confessions, and informant testimony. For example, in *Escobedo v. Illinois* (Id. At 488-89) the Court observed:

> *We have learned the lesson of history, ancient and modern, that a system of criminal law enforcement which comes to depend on the 'confession' will, in the long run, be less reliable and more subject to abuses than a system which depends on extrinsic evidence independently secured through skilful investigation.*

The courts' systems operate in highly structured bureaucratic adversarial frameworks (Wrobleski and Hess, 2003), where courts enjoy a great deal of autonomy within a hierarchical culture (Ostrom, Ostrom , Hanson & Kleiman, 2007). In such systems, the relationship between forensic science and the law is clear, because the sole purpose of forensics is to assist the law in achieving truth by providing physical evidence for courts (Horswell, 2004). However, such a clear relationship is uneasily obtained and sometimes problematic due to differences in goals and methods. The goal of science is to interpret the phenomena of the natural world, whilst the goal of the law is to settle disputes (Bell, 2008).

In terms of methods, science relies on empiricism and refutations to validate and develop scientific theories (Popper, 1989, 2002), where scientists are trained to be objective to the point of scepticism (Inman & Rudin, 2001). On the other hand, the law relies on the 'argument to determine how best to resolve conflicts' (Bell, 2008:4), where legal practitioners are trained to strongly advocate for their party: defendants or claimants (Inman & Rudin, 2001). Hence, in legal terms 'the crucible of truth is argument', where the party that makes the better argument wins. However, in scientific terms, the crucible of truth is observation and experimentation (Bell, 2008:4).

B- Identity as an Image from Public's Perceptions

Over the last two decades, forensic science has 'evolved from a relatively obscure scientific specialisation to a mainstream, accessible and feel-good science for the public' (Robertson, 2008:5). Forensic science enjoys a prominent social stature as a result of media focus and concentration on forensic science topics, news, and TV shows (Houck, 2006; Klein, 2006; Smallwood, 2002).

The focus and concentration on forensic science has resulted in an exponential increase in both the number of students seeking forensic science education, and the number of forensic science courses offered worldwide (Houck, 2006; Mennell, 2006).

C- Academic Identity of Forensic Science

The term forensics is being 'marketed as if it were a famous brand name' where many education providers are 'creating a mass of individuals who will chase the aura of forensics toward a pot at the end of their rainbow that will be filled with disappointment' (Cavallo, 2006: 11). This disappointment is generated when graduates realise that the actual labour market cannot accommodate most of them as there are only few employment vacancies compared with the large number of students graduating every year (Gaensslen, 2003).

Despite the high stature enjoyed within the judiciary and the public, forensic science 'has not enjoyed a similar rise in stature within the academic community' (Jonakait, 1991:6). Forensic science education suffers a great deal of uncertainty in its curriculum structure and pedagogical framework. This is supported by Barclay (2003) who argues about the appropriateness of perceiving forensic science in terms of its role in investigations and the outputs displayed as a result, rather than trying to define forensic science in terms of its epistemology as its definition and identity are too complex. A second support of forensic science disciplinary uncertainty is that forensic science programs are often housed in the chemistry department and treated as one of the applied chemistry majors (Smallwood, 2002) although they may cater for many other sciences and applications that can be invited to solve cases pertaining to law (Inman & Rudin, 1997).

D- The scientific identity of forensic science

Complexity and uncertainty within forensic science identity are not limited to an academic perspective, but extend to the scientific identity of forensic science (Giannelli, 2003; Henderson, 2004; Risinger & Saks, 2003). Giannelli (2006:310) argues in this respect that 'forensic science has not always merited the term **science**'.

Until the last decade of the twentieth century, 'uniquely' forensic forms of inquiry such as fingerprinting, tool marks comparisons, firearms identifications, bite mark analyses and handwriting matches have earned the unquestionable acceptance by courts as unique tools of identification (Houck 2006 & Giannelli 2006). Starting in the 1990s, the American Supreme Court's decision in *Daubert v. Merrel Dow Pharmaceuticals* (1993)- followed by many progeny cases such as *Kumho Tire v. Carmichael* in (1999) and Epstein (2002)- scrutinised many of the 'uniquely' forensic science techniques in terms of their reliability, validity, and legitimacy (Moenssens 1999, Risinger & Saks 2003, Cole 2006, and Giannelli 2006). The *Daubert* Court established a 'reliability test for the admissibility of expert testimony within federal courts' which led to trial courts acting as "gatekeepers" (Giannelli, 2006:311) and being required to deny junk science from access to courtrooms (Jones, 2007). *Daubert*'s 'rigorous standards for judging the admissibility of expert testimony' (Giannelli, 2006:311) are mainly based on:

i. The reliability of the technique itself that is adopted to analyse the evidence in question - that is whether the technique is 'consistent' so that the same results are obtained in each instance (Giannelli, 1980:1201).

ii. The validity of the technique- that is whether 'proposed testimony is supported by appropriate validation' (*Daubert v Merrell Dow Pharmaceuticals 1993 at 590*) of the knowledge base underpinning the technique itself (Cole, 2006).

The counterpart criterion to *Daubert* test is the *Frye* standard (Giannelli, 2006), where *Frye* 'requires that a scientific technique be generally accepted in the relevant scientific community before evidence based on that technique may be admitted in evidence'

(Giannelli, 2006: 311). Before the *Daubert* and *Frye* standards emerged, many forensic techniques had merited unquestionable judicial acceptance for more than 100 years (Cole, 2006). The science basis of these techniques- whether *Daubert* or *Frye*- is now being scrutinized far more closely than ever before (Giannelli, 2006).

Daubert's standards for expert testimony admissibility have exploded arguments among scholars, practitioners, defence lawyers and prosecutors. The emerging arguments mainly circulate around the scientific basis, reliability and validity of many applied forensic techniques, some of which are addressed in Table- 2d.

Table-2d: Arguments Doubting versus Arguments Defending the Science Nature of Forensic Science Techniques	
Arguments Questioning the Reliability and Validity of Forensic Science Techniques	**Arguments Defending the Reliability and Validity of Forensic Science Techniques**
1. Many forensic science techniques lack scientific foundation, reliability, and validity (Risinger and Saks 2003). The forensic profession lacks a truly scientific culture guided by protocols and backed up by experiments and research (Giannelli, 2003). Such techniques (e.g. hair analysis, fingerprinting, ballistics, etc) had generated "oversold and under-researched claims" (Risenger & Saks 2003: 37) and had earned judicial admissibility and acceptance years before *Daubert* requirements' of validity were imposed (Giannelli, 2006). *Daubert* scrutiny has urged more research and experimentation to support the reliability and validity of many forensic techniques; however, most of such research is funded and conducted by law enforcement agencies. Therefore, such 'litigation driven-research' suffers from biased findings that usually aim to support the science basis of the forensic techniques followed by those agencies (Risenger & Saks 2003: 35).	1. Current forensic science techniques rest on a strong science basis and are validated by genuine and reliable research (Houck 2004 and Dwight 2004). Therefore the questioning of whether forensic science is a true scientific endeavour is illogical and unacceptable (Bratton, 2004). In defence of research objectivity and validity, Adams Dwight, Director of the FBI Laboratory in Virginia, argued that forensic science research within the laboratories rests on a strong scientific foundation. Such research addresses Daubert admissibility criteria. Dwight emphasised that the fact that such scientific research is funded by the law enforcement community shouldn't imply that the researchers are biased or that the research results are favoured towards promoting the validity of some forensic science techniques (Dwight, 2004). In defence of Dwight's position, Max Houck (2004) asserted that forensic science research conducted within the FBI laboratories or funded by them is objective.

2. The uniqueness of fingerprinting as an identification tool is doubted. Fingerprint experts support their arguments on the uniqueness of fingerprints from embryology literature. Hence they haven't yet proved the accuracy or validity of fingerprinting. Instead, they have defended its reliability and validity by emphasising uniqueness over accuracy because the first is unprovable whereas the second can be measured and scrutinized (Cole, 2006). Fingerprint evidence rests on foundations that have never been validated because there is no proof that the fingerprints of the world's population do not match (Henderson, 2004; Cole, 2004 & 2006). The only modern study to address this issue was a study undertaken by the FBI which compared 50,000 fingerprint images to each other and then proved that the probability that any two prints selected at random match is nearly zero (Risenger & Saks 2003). This study suffers from significant errors in the study design and analysis and suffers also from being an unpublished litigation biased research (Kaye, 2003). Moreover, the validity of this study is criticised as 50,000 fingerprint images could have come from as few as 5,000 people and do not necessarily represent all the fingerprint images of world population (Henderson, 2004). Fingerprint examiners attempt to avoid the probabilistic analysis of their results in a manner similar to DNA profiling, where every DNA profiling	2. The uniqueness of fingerprinting has been asserted by many scientists for more than 100 years (ÖKRös 1965, Wertheim 2002, and Moenssens 2003). Fingerprints are unique because "it's been well documented in scientific literature that the process of prenatal development causes an infinite variation of individual friction ridge details" (Moenssens 2003:32). Fingerprints' uniqueness can be strongly supported by: 1) the variability of the physiological process through which friction ridges are formed that makes such ridges unique; 2) the fact that no match has ever been documented between any 2 fingerprints from 2 different individuals- even those of two identical twins; and 3) the fact that fingerprints remain unchanged during the lifetime of an individual (Moenssens, 1999). The process of comparing latent fingerprints of unknown origin with inked impressions of known origin is 'an art rather than a science'; however, the 'underlying premise' upon which fingerprinting rest is scientific (Moenssens, 1999:1). Wertheim argues that the fundamental principles of the science of fingerprints have been validated through years of medical research (2002).

report is accompanied with a statistical analysis of results' significance (New Scientists, 2004). Fingerprint examiners have always merited acceptance from courts; therefore, 'they have nothing to gain and everything to lose from validation studies' (Cole, 2006: 129).	
3. Shoe print identification has been challenged by some scholars to be an unreliable technique which lacks peer reviewed publications and which can be conducted by any untrained individual (Armstrong, 2004).	3. Shoe print identification has been defended by a number of scholars and law enforcement agencies to be a widely adopted forensic practice which requires specialised training and has been the subject of various publications within the forensic literature (Armstrong, 2004).
4. The disciplines of firearms and tool mark identification have been targeted by some scholars on: a) the insufficient evidence that tool manufacture would result in unique individuality, the changeable nature of tool surfaces over time which affects individualisation, lack of statistics and databases, and lack of adequate validation (Griffin & La Magna 2002, Saks & Koehler 2005, and Schwartz 2005).	4. Firearms and tool mark identification rests on a firm validated scientific basis. The changes of tool surface over time- if properly accounted for- do neither invalidate the firearms and tool mark disciplines as a science, nor affect their admissibility in courts (Nichols, 2007).

Table-2d

Scepticism about the science nature of a number of forensic science techniques- particularly field techniques- mainly circulate around the weak scientific foundation of these techniques and the lack of unbiased empirical research which prove their validity and reliability (Risinger & Saks 2003; Giannelli, 2003; Cole, 2004 & 2006).

Inman and Rudin defend the science nature of forensic science practice because it meets the four requirements for a practice to be regarded as a science (2001). These requirements are (Inman & Rudin, 2001):

- **Scientific Methodology**: Forensic science follows the scientific method of hypothesis testing in every investigation. Forensic scientists use either the null hypothesis, or a Bayesian framework to examine hypotheses. For example, one forensic expert may claim that "this bullet came from that gun". This is called the null hypothesis. If this expert performs testings, and repeatedly fails to disprove the null hypothesis, then s/he accepts the null hypothesis as being true. If the testing does, in fact, disprove the null hypothesis, the expert must reject it and accept the alternate hypothesis: "the bullet was not fired from the gun". Another expert may use a Bayesian framework, where competing hypotheses are compared and their relative likelihoods are calculated.

- **Dynamicity**: Forensic science is dynamic because newer and more discriminating techniques are regularly adopted to distinguish between two items that were previously indistinguishable using older techniques. For example, forensic biology now can distinguish between two individuals with the aid of DNA profiling. Initially, blood typing was not always a reliable and efficient tool in forensic biology for the differentiation between two individuals, especially if those individuals possessed the same blood type, type "A" for instance.

- **Durability**: Forensic science is durable because new technologies advance existing methods and applications.

- **Reproducibility**: Forensic science is reproducible as the confirmation of results often takes the form of independent review, either by another analyst in the laboratory or by an expert assisting an opposing counsel.

Inman and Rudin (2001) argue that forensic science, similar to engineering and medicine, is an applied science and enjoys all the characteristics of an applied science except that it lacks an experimental nature. This is because the results obtained from a forensic sample are those of an ‘examination or analysis, not an experiment’. The analyst is ‘gathering facts about a piece of evidence that will later be combined with other facts and assumptions to form a theory of what happened in the case’ (Inman & Rudin; 2001:8).

Despite the arguments whether some forensic science techniques are or are not valid and reliable sciences, almost all scholars do agree on the necessity for more research, funding and publication within the various areas of forensic science (Moenssens, 1999, Risenger & Saks 2003; Houck 2004 & 2006; Giannelli 2003 & 2006).

On the issue of identity uncertainty, Terrence Kiley argues that the identity of science in forensics when dealing with a criminal case is not the same as that when dealing with a civil matter. Kiley defends his argument as follows: 1) civil law and criminal law are two distinct areas in legal practice; 2) In civil cases, forensic science is usually involved in product liability and associated personal injury disputes where science is focused on ‘issues of causation’; 3) In criminal cases, forensics scrutinizes and analyses the ‘physical dynamics’ that created a crime scene by covering a wide range of sciences, applied sciences, and other forms of inquiries in order to ‘generate material facts’, such as DNA identifications and fingerprints matching, that would help identify the offender. Kiley asserts that these types of issues – science of causation *versus* science of experimenting and fact generating- have been the ongoing focus of United States Supreme Court decisions, in an attempt to finalize a comprehensive definition of the ‘science’ upon which forensics operates (Kiley, 2006:4).

Since its inception, forensic science, according to Inman and Rudin, is probably 'the least understood and the most misunderstood of all scientific disciplines' (2001: 22). However, all the addressed debates in this subsection raise questions about the ontological nature of forensic science, an inquiry which this research will undertake at later stages of data analysis.

E- The Occupational Identity of Forensic Science within the Police Arena

The management model of forensic science services may vary from an exclusive military/police management, a combined military-civilian management, to a completely independent civilian management (Horswell, 2004). The first two management models are much more adopted than the third one (Horswell, 2004). In terms of forensic roles, these roles are often distributed between sworn and unsworn police members, where sworn police members often occupy field positions, whilst scientists- unsworn police members- often occupy laboratory positions (Wrobleski & Hess, 2003).

Many law enforcement agencies still consider forensic science tasks as constituting one of the many 'specialised roles' of the police (Wrobleski & Hess, 2003:202). During recent years, there has been a move towards the civilianisation of the forensic science field (Horswell, 2004). This move towards civilianisation may be opposed by some police departments as it might be perceived by them as a 'threat to those sworn personnel who occupied positions that have since been civilianised' (Hunter, Barker, & Mayhall, 2004:113).

In combined management models, where forensic roles are distributed between sworn police officers and scientists, resentment and conflict may occur (Roberg & Kuykendall, 1997). Conflict may exist between:

- a 'quasi-military' culture (Hunter et. Al, 2004:104) of command, control, and unavoidable violence (Coady, James, & Miller, 2000) represented by sworn police officers, and
- a civilian culture represented by scientists.

Despite the adopted management model of forensic science, it is generally accepted that maximising the potential for forensic science to contribute to crime solving requires close proximity to police. Such proximity facilitates close cooperation between field and laboratory practitioners (Horswell, 2004).

2.4- The Two Bodies of Literature: An Informative Landscape

In the first body of literature, three scholars have been identified as the major leading and informing theorists of the research analyses and discussions. These scholars and their respective notions- of relevance to the research conceptions- are summarised in the Table-2e.

Scholar	Relevant Notions
William Pinar	- Conception of the curriculum as the site upon which generations struggle to define themselves, - Notion of curriculum as a complex conversation between various groups.
Thomas Kuhn	- Perception of the reigning paradigm of a science field as being a large body of interconnecting knowledge, methods, assumptions, and received beliefs which might shift to a new re-defined body (paradigm shift) during periods of scientific and technological advancements (scientific revolution), - Notion of exemplars as being the set of common solutions to common problems/puzzles in a scientific field which need to be known by students, novice practitioners, and practitioners in such a field.
Basil Bernstein	- The notion of social power and control exerted by stakeholders of an educational code in shaping the curriculum and pedagogy of such a code. -The notion of pedagogical discourse, where discourse between initial concepts re-contextualises and re-conceptualises these concepts by transforming them from an initial site (prior to discourse) to a new site (consequent to discourse). The notion of pedagogical discourse will be mainly used as a framework for data analysis.

Table-2e

Thomas Kuhn is favoured over other science philosophers as one of the major leading scholars in this research mainly because the social dimensions of his:

- reigning paradigms which invite Bernstein's notion of 'power and control' on the power and control a community of practice might adopt in accepting assumptions and observations as part of its body of knowledge or paradigm and what are not, and
- paradigmatic shifts which require "Pinarian" conversations and discourses amongst the various stakeholders of the paradigm.

However, Karl Popper's notion of refutation and conjecture will be used in the final analyses and discussions to challenge the scientific identity of forensic science versus its legal identity: refutable scientific knowledge versus scientific evidence "beyond reasonable doubt". In addition, Maxwell's aim-oriented empiricism will be adopted to relieve the crisis a number of forensic science techniques (e.g. fingerprinting and handwriting examination) suffers from concerning their suspected science nature because of the assumptions of uniqueness, validity, and reliability claimed for such techniques. Bernstein's notion of 'power and control' will be invited into Maxwell's aim-oriented empiricism in an attempt to identify the influence of 'power' on 'aim' and the 'control' such power possesses in "orienting forensic science empiricism".

The second body of the literature examined the determining factors of forensic science education: knowledge, practice, and identity. Reading through and across the two bodies of literature the following questions and arguments arises:

- If forensic science is a scientific field of knowledge, then what are the **reigning paradigm** and consequent **exemplars** which reflect the knowledge, practice, and identity of this field?

- What are the current challenges which face the current generation of forensic science practitioners, educators, and members of associated professions **in defining themselves** through a curriculum which organises and transmits forensic science **paradigm and exemplars**? And how can a **complex**

conversation occurring between these various **social groups** be approached and simplified?

- How do the **decisions** about the curriculum and pedagogy of forensic science education reflect the power of the various forensic **social groups** and reflect their positions within a forensic science **paradigm?**

In other words, if curriculum is a conversation, a complex one, then what sort of discourse needs to take place between the different forensic social groups about a curricular approach capable of reflecting the forensic science paradigm and emphasising forensic science exemplars? These education questions about forensic science may best be answered through approaching the determining factors of forensic science education: forensic science knowledge, forensic science practice, and forensic science identity.

Approaching the determining factors of forensic science education may create insights into the ontological nature of forensic science. In other words, whether or not forensic science is purely scientific or is more of a 'social practice' (Connell, 1987, 2000; Connell, Ashenden, Kessler, & Dowsett, 1985) comprising a complex interaction between structure and human agency: forensic practitioners, police, and the members of the judiciary. Consideration of the ontological nature of forensic science may provide insights on whether or not education inquiries into forensic science education can be handled purely as an epistemological matter.

This ontological-epistemological understanding may be critical in answering the research questions and in reaching a set of decisions or recommendations on how best to organise forensic science curriculum in higher education.

2.5- Chapter Summary

Forensic science is a pluri-disciplinary field under which science, scientific applications, and uniquely forensic forms of inquiry are associated with law in a complex and uneasy mating. Forensic science resembles engineering and medicine as it uses the foundations of mathematics and natural sciences to study and analyse physical evidence. However, forensic science, in terms of its identity as an academic field of study and a professional field of practice, is not as defined as engineering and medicine.

Forensic science suffers a great deal of uncertainty and complexity as an educational activity. Such uncertainty mainly emerges from ambiguity in the nature of the knowledge base, practice, and identity of forensic science. Therefore, this research aims to clear such ambiguity in order to map the complexity of forensic science into implications of forensic science education. In order to achieve such an aim, this research undertakes a document analysis of the published curricula of 190 forensic science courses/programs offered worldwide. Such an analysis provides the research with insights into the current status of forensic science education. This research then takes such insights as a starting point for semi-structured interviews with forensic science educators, practitioners, and members of associated professions. These interviews explore the interviewees' informed opinions and perceptions of forensic science education in terms of the incorporated knowledge base, nature of practice, and reflected identity.

The following chapter (Chapter 3) addresses the research methodology of this study. The research methodology is conducted in two stages. The first stage is the document analysis. The second stage is the semi-structured interviews. This research aims by cross-comparing the themes/implications generated by these two stages to answer the major research question and generate insights and implications into forensic science education.

Chapter 3: Methodology

3.1- Introduction

This research is a study about forensic science education in terms of the knowledge base, the nature of everyday practice, and the identity of forensic science. The major and supporting research questions of this study are:

Major Research Question:

"How do the Curriculum and Pedagogy of Forensic Science Courses Reflect the Practice, Knowledge and Identity of the Forensic Science Field?"

Supporting Research Questions:

1- How do published curriculum documents of a selected set of current forensic science courses portray the nature of the practice, knowledge and identity of the forensic science field?

2- What are the perceptions of forensic science practice, knowledge and identity held by a selected group of Australian forensic practitioners, educators and members of profession?

3- What are the perceptions of current forensic science courses held by a selected group of Australian forensic practitioners, educators and members of profession?

4- In what ways do those perceptions indicate the complexity, if any, of forensic science and forensic science education?

5- How can a comparison of the document analysis of current forensic science courses with the analysis of interviewees' perceptions provide a curriculum and pedagogical framework for forensic science education?

The major research question and associated supporting questions acknowledge forensic science epistemological and curricular complexity in order to generate understandings and implications for forensic science education.

In order to answer the major research question and associated supporting research questions, this study has adopted a mixed-method approach: an overall qualitative methodology informed by a minor quantitative approach. This methodological approach will address the research questions and create the framework which governs the selection of strategies for data collection, coding, and analyses.

This chapter aims to detail the research methods and techniques adopted for data collection, coding, analysis and interpretation after addressing the theoretical framework which governs the selection, adoption, and implementation of those methods and techniques.

3.2- Methods of Inquiry in Education

Qualitative and quantitative paradigms comprise the main methods of inquiry in education (Miles & Huberman, 1993; Campbell, McNamara & Gilroy, 2004). These paradigms logically ‘connect concepts and propositions' to provide researchers with: a) guidance through ‘theoretical perspective or orientation' (Morse & Field, 1995: 243) and b) frameworks for viewing the world based on a set of assumptions about the nature of truth and reality (Sparkes, 1992).

Quantitative research is used when the collected data appear ‘more in numbers rather than words’ and is mainly analysed using statistics. On the other hand, qualitative research is used when ‘the data concerned appears in words rather than numbers' and is analysed using coding frameworks (Miles & Huberman, 1993: 21). Whilst both methods focus on the ‘variation in a situation, phenomenon, problem, or issue’, qualitative research is concerned with establishing such a variation whereas; quantitative research is concerned with quantifying it (Kumar, 2005: 12).

Qualitative research, as opposed to quantitative research, deals more with uncertainties (Savin-Baden & Major, 2010). However, this does not make qualitative research any less important than quantitative research, because it deals with the ‘wisdom’ which underlies these uncertainties in ‘stance, approach and space’ (Savin-Baden & Major, 2010:5).

3.3- Qualitative Research: Definitions and Characteristics

Qualitative research is an ‘intellectual activity’ (Richards & Morse, 2007: 8) and ‘inquiry process of understanding’ (Creswell, 1998:15) which aims to both capture people’s perceptions, and interpretations of the complexity of their world, and to investigate their understanding of events from their own viewpoints (Burns, 2000). Qualitative research adopts methods such as case study, interviewing, interpretive analysis, and participant observation in order to answer a research question and/or solve a research problem (Denzin & Lincoln, 2003).

The three features which characterise qualitative research are (Clifford, 1990:76):

i. *The focus*, which is commonly about unearthing new knowledge or getting new insights and so it is at the *inductive* end of knowledge development;
ii. *The perspective*, where consideration is taken from the *emic* perspective, that is, from the perspective of the individual participants being studied, as distinct from quantitative research designs which use the *etic* perspective: the perspective of the researcher or outsider; and
iii. *The scope*, which is more *holistic* as the focus on the individual includes consideration of the context in which the research takes place.

3.4- Research cases which requires qualitative methodology

“When should a researcher adopt a qualitative methodology?” is a question that has been approached by various scholars. Richards and Morse (2007: 27) argue that research cases- such as ‘patterns of behaviours’ and ‘policy areas’- which possess ‘complex unstructured data’ demand a qualitative approach to derive new understandings from such data. Qualitative research is adopted when the researcher(s) wishes to observe, describe, and interpret experiences, ideas, attitudes, perceptions, beliefs, and values (Wisker, 2001).

The two major reasons for a researcher to work qualitatively are:

i. Research Nature Demands it

   The nature of some research demands a qualitative approach because it requires the researcher to: a) investigate a social or human science area which does not possess firm guidelines or specific procedures and is constantly evolving and changing (Creswell, 1998: 17), b) understand an area where little is known or previously offered understanding appears inadequate, c) make sense of complex situations and changing/ shifting phenomena, d) learn from the participants in a setting or a process the way they experience it, the meanings they put on it, and how they interpret what they experience, e) construct a theory or a theoretical framework that reflects reality rather than the researcher's own perspective, and/or f) discover central themes and analyse core concerns relating to a particular phenomenon (Richards & Morse, 2007: 30).

ii. Data requires it

   Some data can only be collected through particular strategies (e.g. observation and interviewing) of a qualitative nature (Richards & Morse, 2007). Such data require the researcher to adopt qualitative practices such as: a) spending a long time in the field to collect extensive data and/or b) engaging in complex, time-consuming processes of data analysis in order to sort and reduce large amounts of data to a few themes or categories (Creswell, 1998).

A general misconception considers qualitative methodology as an easier substitute to quantitative approaches, because it can avoid complex statistics and calculations. By contrast to this general misconception, the qualitative approach should be seen as a complement to quantitative methods, because it applies its own characteristics and features and possesses its own requirements which might be even more demanding, complex, and time-consuming than quantitative forms (Creswell, 1998; Richards & Morse, 2007).

3.5- Strategies within Qualitative Inquiries

Qualitative research employs six analytic strategies (Miles & Huberman, 1994: 9):

- *Collecting* and *coding* data as data records are created,
- Recording *reflections* and insights
- *Sorting* and *sifting* through the data to identify similar phrases, relationships, patterns, themes, distinguishing features, and common sequences,
- *Seeking patterns or processes, commonalities and differences,* and extracting them for subsequent analysis,
- *Gradually elaborating a small set of generalisations* that cover the consistencies discerned in the database, and
- *Converting these generalisations* into a formalised body of knowledge in the form of constructs or theories.

3.6- The Qualitative Nature of the Study

This study is largely of a qualitative nature for two main reasons: the nature of the research demands a qualitative approach and the type of data required by the research demands qualitative techniques and strategies for collection, coding, and analysis. First, the research is concerned with investigating forensic science education which is a new emerging field of education where little is known or published. The nature of the research requires the researcher to generate understandings and discover central themes relating to forensic science education. Second, most of the research data emerges from the perceptions of selected participants about the nature of forensic science knowledge, forensic science practice, and forensic science identity. Therefore, such data requires hours of interviewing for collection and consequent long periods of coding and analysis to categorise data into conceptual attributes and themes. Hence, qualitative strategies are adopted to deal with such data.

3.7- Choice of Methodological Approach

This research focuses on a new developing social science field of inquiry: forensic science education. This study aims to generate understandings about: a) the knowledge base of forensic science, b) professional practices within forensic science; and c) the identity of the forensic science field, in an attempt to generate implications about forensic science education and the ways in which knowledge and understanding about forensic science are created, organised and transmitted. The research intends to generate those understandings by locating itself within both the curricula of current forensic science courses/programs offered worldwide, and the perceptions and opinions held by forensic science educators, practitioners and members of associated professions (e.g. barristers and police) about forensic science knowledge, practice, and identity.

This study is investigating a new emerging field of education where little is known or published. Such an investigation would generate complex and unstructured data. Therefore, an overall qualitative approach is best suited to: a) address the research topic, b) fulfil research aims, and c) answer research questions by adopting both document analysis and semi-structured interviews for data collection, coding and analysis.

The major research question and associated supporting research questions are set because understandings and conceptions of this new emerging field are best generated by:

a. conducting a document analysis to study the current status of forensic science education through examining current academic forensic science programs,

b. interviewing forensic science educators, practitioners, and associated personnel, and finally
c. cross-comparing and analysing themes generated by both document analysis and semi-structured interviews.

In order to collect, code, and then analyse sufficient and relevant data, the methodology passed through two stages: document analysis and semi-structured interviews. The inclusion of two stages in data collection initiated the practice of triangulation which has been recommended by many researchers and educators (Chenail, 1997; Burns, 2000; Denzin & Lincoln, 2000; and Mathison 1988). In the second stage of the research methodology, the interviews were conducted with three different groups of participants: educators, practitioners, and members of associated professions. This also promoted the triangulation practice, for Wolcott (1988, p. 192) asserts that a researcher should 'never for a minute rely solely on a single observation, single instrument, or single approach [for] the strength of field work lies in its "triangulation" obtaining information in many ways rather than relying on one'.

The first stage of the research methodology incorporates a small-scale quantitative inquiry, where statistics are used to generate frequency tables and bar charts for data presentations, within a broader qualitative research. This makes the methodology adopted in this research more of a 'mixed methods' approach rather than a purely qualitative approach (Richards & Morse, 2007: 93). Having adopted a minor quantitative component through document analysis, the research then employs qualitative strategies and techniques in data collection, coding, and analysis throughout the two phases of the methodology (document analysis and semi-structured interviews). The use of the quantitative approach- though limited- supports the overall qualitative feature of the methodology in answering the research questions.

This research, as emphasised in chapter 1, will focus on a **working definition** of forensic science that is confined to the application of physical sciences, biological sciences, and other explicitly forensic forms of inquiry and techniques (e.g. crime scene processing, fingerprinting, etc) to matters pertaining to both criminal and civil law; i.e. criminalistics. Such restriction by the working definition will simplify the conduct of this research. However, it cannot ignore the epistemological complexity of forensic science which will be a challenge for the designers of academic forensic science programs.

3.7.1- Document Analysis

The first stage of the research methodology is document analysis. Document examination is one of four data collection methods: interviewing, instrument administration, observation, and document examination (Sproull, 1995). Document analysis has been highlighted by many scholars as one of the efficient qualitative methods for data collection and interpretation (Barcan 1993; Kerlinger 1986; Anderson 1997; Sproull, 1995).

Documents can be analysed in a quantitative and/or a qualitative way (Sage, 2009). Document analysis as a method can either stand-alone or be a complementary strategy to other methods (e.g. interviews) within the one research (Sage, 2009). In this research, document analysis was employed as a complementary strategy to semi-structured interviews which comprised the second stage of the research methodology.

John Codd (1988) argues that analysis of documents needs to go beyond the analysis of texts to include that of the contexts in which these texts were written. Documents are 'not a simple representation of facts or reality' (Sage, 2009: 257). An individual or an institution produces documents to be used in certain forms to fit a certain purpose; hence, a document should not be analysed in isolation from the profile(s) of the author(s), purpose of the document, and the audience targeted by such document (Sage, 2009). Documents can be seen as a discourse of policies, structures, aims, intentions etc (Codd, 1988).

Codd's theory of documents as discourses is informed by his reading of Saussure's work (1974) "Courses in General Linguistics", where Saussure argues that words in documents are not only expressions of pre-existent ideas and assumptions, but they also comprise sets of social practices which connect and give meaning to individuals and things.

Document analysis has been chosen to constitute the first stage of the research methodology for the following reasons:

i. Forensic science is one of the relatively new fields of practice and higher education, where little has been known or published (Houck, 2006; Mennell, 2006). Moreover, the numbers of programs offering forensic science are steadily increasing (Smallwood, 2006, Houck, 2006). Therefore, it is essential to conduct an investigation on the current status of forensic science education. Such an investigation may best be done through a document analysis of the curricula of current forensic science courses/programs.

ii. The typology which has previously been applied in chapter 1, has prompted the further investigation into published forensic science curricula to generate deeper understandings about:

   a) The knowledge base incorporated within these curricula,
   b) The place and extent of practice within these curricula and
   c) The identity of the field as reflected by the considered curricula.

iii. The examination of the published curricula of current forensic science courses/programs is essential in identifying 'grey areas' within forensic science epistemology and education. These areas await clarifications via more detailed investigation in the second stage of the research methodology. Hence, the questions of the semi-structured interviews were designed in a manner which ensures clarifications of these grey areas and the generation of insights into forensic science education and curriculum.

iv. The minor quantitative component within the document analysis generated statistical charts of significance for forensic science education. These charts were used as prompts for the interviewees during the second stage of research methodology. This initiated cross-comparison between the two stages of the methodology.

Document analysis commenced with a list of 190 published forensic science academic programs offered by various institutes worldwide. A selection strategy was then adopted to allow for the final selection of 15 programs which were thoroughly studied and analysed.

3.7.1.1- Data Collection

The list of the 190 worldwide forensic science programs was obtained from a number of forensic science organisations and a number of publications as follows:

- American Academy of Forensic Sciences (AAFS) [Electronic[30]].
- The National Institute of Forensic Science (NIFS) [Electronic[31]].
- Reddy's Forensic website [Electronic[32]].
- Training programs offering forensic science (Camenson, 2001: 136)
- A Selection of institutions offering programs with forensic interest (Genge, 2002: 294).

John Scott suggests four criteria to help researchers decide whether or not to include a specific document in their research (1990:6):

- Authenticity: is the evidence genuine and of unquestionable origin?
- Credibility: is the evidence free from error and distortion?
- Representativeness: is the evidence typical of its kind, and, if not, is the extent of its untypicality known?
- Meaning: is the evidence clear and comprehensive?

In order to meet Scott's Selection Criteria, a multi-stage selection process was established to select 15 programs out of the initial list of 190 programs. These 15

[30] http://www.aafs.org/default.asp?section_id=resources&page_id=colleges_and_universities, Accessed: 02/06/06

[31] http://www.nifs.com.au/F_S_A/FSA_frame.html?Courses.asp&1, Accessed:02/06/06

[32] http://www.forensicpage.com/new05.htm, Accessed:07/06/06

programs were thoroughly analysed. In addition to meeting Scott's Selection Criteria, the multi-stage selection process ensured that the selected forensic science programs were:

1. Explicitly identified as 'forensic' or explicitly connected with forensic science practice and fall within the research's working definition of forensic science.

2. Selected from native English-speaking countries which share the same Common Law heritage on both the legislative and judicial levels.

3. Rich-information so that they produce through their outlines possible conceptual implication(s) of curriculum and pedagogy attributes of identity, practice and knowledge.

4. Representative of the various academic institutions offering these courses/programs worldwide.

5. Representative of all levels of offers: non-award degrees, undergraduate, postgraduate and both undergraduate and postgraduate.

6. Inclusive of Australian forensic courses/programs as the research is conducted in Australia and the semi-structured interviews will be conducted with Australian interviewees.

3.7.1.2- Data Coding and Analysis

During the selection process of the final 15 programs starting from a list of 190 programs, quantitative data analysis was applied on data collected to generate some descriptive statistical charts and graphs using Microsoft Excel (Campbell et al., 2004; Kumar, 2005). The statistical charts analysed the distribution of forensic science programs over: a) various administering departments (e.g. chemistry, biology, criminal justice, or standalone department) and b) various levels of academic offer (e.g. non-award, undergraduate, postgraduate, undergraduate and postgraduate).

Subsequent to the selection of the final set of 15 programs, collected data was coded according to a framework (Appendix C) which emphasised possible conceptual attributes revealed by these courses in relation to forensic science knowledge, practice, and identity. Qualitative analysis considered deeper curriculum and pedagogy factors including the relationship between course aims and objectives on the one hand and course content and delivery of such content on the other. Qualitative data analysis was conducted using Microsoft Word tables which show conceptual attributes of complexity to forensic science as indicated by Appendix C. The qualitative analysis was then related to the quantitative analysis to generate themes of reported curricular and pedagogical features of the selected courses.

The conceptual attributes and implications generated by the document analysis guided the second phase of the research methodology (semi-structured interviews) and were cross-compared and examined with the attributes and implications emerging from the interview data. Document analysis is fully addressed and detailed in the following chapter (Chapter 4).

3.7.2- Semi-Structured Interviewing

The second stage of the research comprised semi-structured interviews. Interviewing is a common research procedure used to elicit information about people's opinions, attitudes, values, perceptions, beliefs, and behaviours (Kumar, 2005; Sproull, 1995) about issues, topics, and experiences of relevance and significance to the research (Mason, 2002). Interviews involve some form of 'conversation with a purpose' (Burgess, 1984:102). There are many different types of interviews, ranging from structured (e.g. surveys), semi-structured, to unstructured interviews (Campbell et al., 2004). Semi-structured interviewing has been favoured in the methodology over unstructured and structured interviewing, because this approach: a) offers a guide that can be given to the interviewees so that the content of the interview focuses on the crucial issues of the study (Burns, 2000), b) avoids ‘fixed wording or ordering of questions’ as is the case in structured interviews (Burns 2000: 424), and c) keeps away from ‘open ended breadth of data’ as is the case in unstructured interviews (Denzin & Lincoln, 2000:652). The content of the semi-structured interviews concentrates on the vital issues that comprise the research questions: concepts of forensic science knowledge, practice, and identity.

The adoption of semi-structured interviews for data collection is appropriate when researchers know ‘enough about the phenomenon or the domain of inquiry in question’ to develop questions which would frame discussions about the topic of study in advance of interviewing, but not enough to ‘be able to anticipate the answers’ (Richards & Morse, 2007: 114). Given the researcher’s prior knowledge and stance, semi-structured interviews were the most appropriate qualitative method to assist the researcher in collecting relevant and significant data capable of answering the research questions.

The semi-structured interviews were guided by the findings of the document analysis as a starting point for prompting interviewees’ perceptions about the nature of knowledge, practice, and identity of forensic science, based on their experiences, understandings, and standpoints.

3.7.2.1- Research Participants

The participants in the semi-structured interviews were chosen to be Australian participants as the research was conducted in Australia. The selected participants represented three categories:

- The first category of interviewees comprised 4 forensic science educators who possessed experience in teaching forensic science or forensic-related subject(s) and were likely to have informed opinions about curricula and pedagogies adopted in forensic science education. The participants in this category were selected with respect to their experiences, publications and contributions in forensic science education.

- The second category of interviewees included 6 forensic science practitioners who worked in various areas within the forensic science field. In order to represent the two major practices within forensic science and the various specialisations within these practices, the interviewees were selected to comprise:

  - 3 field practitioners (a crime scene investigator, a vehicle examination expert, and a firearm expert), and
  - 3 laboratory practitioners (2 forensic biologists and 1 forensic chemist)

- The third category of interviewees comprised 4 members of professions associated with forensic science: a barrister (prosecutor), a barrister (defence), a forensic psychologist, and a senior detective (police officer). The inclusion of the barrister category is necessary due to the direct interaction between these personnel and forensic practitioners during trials, when forensic experts present their evidence in a court of law. The inclusion of a detective and a forensic psychologist is justified by the direct interaction between these personnel and forensic practitioners on the crime scene and during the investigation process.

Interviewees were selected and contacted through professional networking: Victorian Forensic Science Centre, National Institute of Forensic Science (NIFS), The Australian and New Zealand Forensic Science Society (ANZFSS), Victoria Barristers (Vic Bar), and Victoria Police. Interview lengths were 1.5- 2 hours on average. This period is considered to be an optimum time frame for gaining rich interview data (Richards and Morse, 2007).

3.7.2.2- Interview Rationale

The interview questions were designed to open up for examining the interviewees' perceptions about forensic science education and how such an education maps forensic science complexity and reflects forensic science knowledge, practice, and identity. The interview questionnaires for all three groups of participants were based on the one theme: identifying conceptual attributes and themes for each of the three determining factors of forensic science education: forensic science knowledge, practice, and identity. However, the wording and focus of each questionnaire were set differently in a manner to recognise the characteristics of each group of participants and its relation to forensic science. For example, interview questions set for the second group participants mainly focused on the participants' everyday practice on the crime scene, in the laboratory, and in court, whilst those set for the third group participants concentrated on participants' regular interactions with forensic practitioners at the crime scene and/or in court.

The questionnaire set for the first group participants (Appendix D) focused on identifying interviewees' informed opinions and perceptions about forensic science education based on their everyday teaching and research experiences and interactions with forensic science practitioners and members of associated professions. These questions also prompted their overall viewpoint of the identity of forensic science as a field of practice and as a developing higher education field of study and research.

Interview questions designed for the second group participants (Appendix E) focused on their everyday practice, activities, and tasks in the field, in the laboratories, and at court. These questions aimed to identify: a) the competencies and skills applied by participants to perform such activities and tasks, b) the training and/or education through which these competencies and skills were acquired, c) the relevance of previous schooling or higher education, if any, to the expertise of these participants and the way they perform their roles, and d) their general overview in relation to forensic science as a field of practice.

The third group participants were interviewed (Appendix F) about their regular contacts and experiences with forensic science practitioners. Interview questions to participants of this group focused on their: a) expectations of forensic scientists, b) perceptions of the knowledge base and competencies forensic science practitioners should display, and c) overall viewpoint of forensic science identity.

All interviewees were also asked to comment on the two reports generated by the document analysis about the distribution of forensic science courses with respect to various administering departments (Report A) and the distribution of forensic science courses with respect to the various levels of academic offer (Report B).

3.7.2.3- Data Collection and Transcription

Before conducting any interview, approval from the Human Research Ethics Committee of Victoria University was sought and granted. Prior to every interview, interviewees were given a plain language information sheet (Appendix G) which briefly described the aims of the research, addressed the research problem, and summarised the research methodology. Interviewees were also asked to sign a consent form (Appendix H) in compliance with the ethics requirements set by the Ethics Committee.

Interviews were conducted and data was collected via tape-recording. Both field notes (descriptive details about the interview) and reflective notes (personal insights, thoughts, feelings, and impressions) were also recorded. These notes assisted the researcher in keeping the interviews appropriately ‘focused’ and were also invaluable in the latter analytical phase of the study. Data collected from interviews was transcribed using Microsoft Word. Transcribed data was then organised into three categories: data collected from a) educators, b) practitioners, and c) members of associated professions.

Identities of the interviewees have been kept anonymous in compliance with the ethics requirements set by the Ethics Committee. Interviewees' identities were referred to using alphanumerical codes as follows:

- The four forensic science educators were respectively referred to as EP1, EP2, EP3, and EP4.

- The six forensic science practitioners were respectively referred to as PP1, PP2, PP3, PP4, PP5, and PP6.

- The four members of associated professions were respectively referred to as AP1, AP2, AP3, and AP4.

3.7.2.4-Data Coding and Analysis

Data coding and analysis were conducted over three chapters:

- Chapter 5 coded and analysed the transcribed data relating to forensic science knowledge,

- Chapters 6 coded and analysed the transcribed data relating to forensic science practice,

- Chapter 7 coded and analysed the transcribed data relating to forensic science identity.

Transcribed data was coded (Microsoft Excel) into qualitative conceptual categories which were identified by the researcher as being major descriptive conceptions of forensic science knowledge, practice, and identity. The connotations of each category were addressed with representative quotations from the interview data to convey the nuances of meaning as is customary in data coding and analysis in a qualitative research (Creswell, 1998; Sproull, 1995). In each of the identified categories of description, the position of each group of participants from such category of description was addressed in a separate subsection.

Inter-categorical analysis was then conducted between the perceptions of the three groups of participants to summarise the overall position of participants from each of the identified categories of description. In doing so, the research adopted Pinar's position (2004) in initiating a conversation between the various participating groups about conceptions of forensic science and forensic science education. Hence, inter-categorical analysis is nothing but a 'complex conversation' between the perceptions of each of the three groups of participants about the identified categories of description.

Finally, cross-comparison synthesis was conducted amongst the identified categories of description to generate themes relating to forensic science knowledge (chapter 5), practice (chapter 6), and identity (chapter 7). Each of the identified themes was generated following cross-comparison synthesis between at least two inter-categorical attributes emerging from the inter-categorical analysis. In doing so, the research adopted Bernstein's pedagogic device (2000), where themes were only identified after recontexualising and reconceptualising the identified inter-categorical attributes following a discourse between at least two different categories of description. Consequent to their identification, themes were reconstructed into exemplars which added a practical component to the themes. Implications for forensic science education were finally generated to respond to the identified themes and exemplars.

Coding started as descriptive, progressed by topic, and ended up as analytic (Miles and Huberman 1994; Richards and Morse, 2007). The analytical strategy adopted in each of chapters 5, 6, and 7 is represented by Figure-3a. Conducting analysis of the transcribed data over three chapters provided a more structured methodology, a simpler approach to data analysis, and a more readable account of the data analysis.

3.7.3- Final Analysis and Discussion

Cross- comparative analysis between the identified themes from the document analysis and those from the semi-structured interviews was finally conducted in Chapters 8 and

9. Discussions about the nature of forensic science were carried out in Chapter 8. Discussions about the nature of forensic science education which responds to the nature of forensic science knowledge were conducted in Chapter 9. These discussions took the form of a pedagogical discourse across the identified themes of both the document analysis (Chapter 4) and the semi-structured interviews (Chapters 5, 6, and 7).

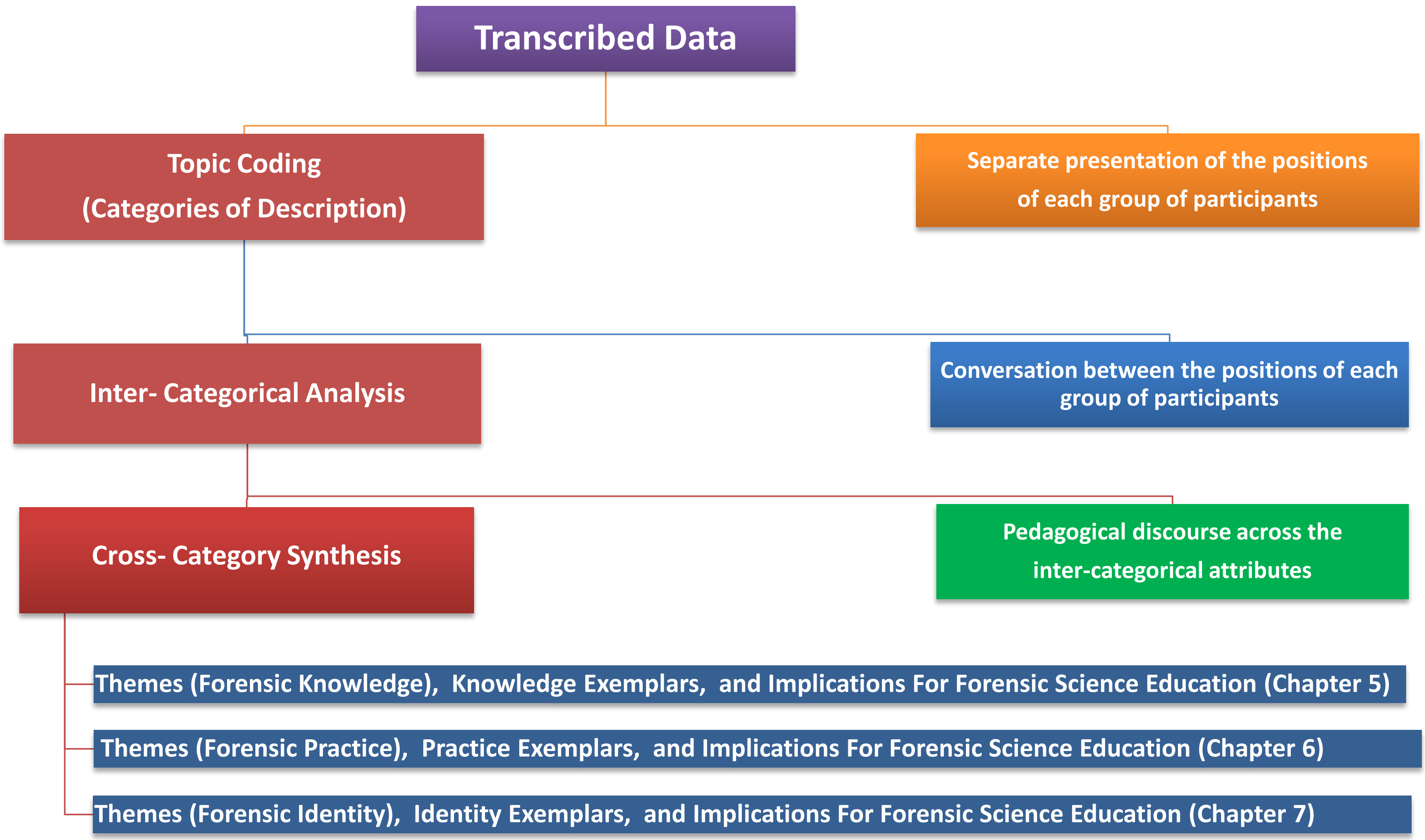

Transcribed Data
Topic Coding
(Categories of Description)
Separate presentation of the positions of each group of participants
Inter- Categorical Analysis
Conversation between the positions of each group of participants
Cross- Category Synthesis
Pedagogical discourse across the inter-categorical attributes
Themes (Forensic Knowledge), Knowledge Exemplars, and Implications For Forensic Science Education (Chapter 5)
Themes (Forensic Practice), Practice Exemplars, and Implications For Forensic Science Education (Chapter 6)
Themes (Forensic Identity), Identity Exemplars, and Implications For Forensic Science Education (Chapter 7)

Figure-3a

Discussions in Chapters 8 and 9 aimed to identify:

1. Areas of agreement and disagreement between document analysis and semi-structured interviews.
2. Areas of agreement and disagreement amongst forensic science educators, practitioners, and members of associated professions.
3. Points of practice and knowledge agreement or contradiction amongst groups of participants.
4. The questions and dilemmas facing forensic science educators as they attempt to construct forensic science curriculum in higher education.
5. Issues and themes relating to forensic science education in terms of the way the curriculum and pedagogical frameworks of current forensic science courses present the knowledge base which relates to the nature of forensic science practice, reflects forensic science identity, and tends to resolve the dilemmas and contradictions which the interview research phase identifies.

The summary of findings and recommendations is summarised in the final chapter of the thesis (Chapter 9).

3.8- Methodology Limitations

Document analysis considered data related to the organisation and delivery of forensic science courses from the information present on the websites of the education providers offering these courses. However, course coordinators do not necessarily publish on the internet all the curricular and pedagogical strategies which organise their courses or reflect the courses' nature. This constitutes the first limitation of the methodology.

A second limitation arises from the difference in scopes between the two stages of the methodology. Document analysis considered various forensic science programs worldwide. On the other hand, semi-structured interviews represented the perceptions, informed opinions, and understandings of Australian personnel about forensic science knowledge, practice, and identity. Hence, document analysis possessed an international scope, whilst semi-structured interviews possessed a national scope. This limitation is mitigated by the international experiences of most of the research participants.

3.9- Chapter Summary

The aim of this study is to generate understandings about the nature of forensic science and the consequent nature of forensic science education. By applying an overall qualitative methodology to investigate this developing field of practice and study, the research has sought to gain the perceptions of participants about the way this knowledge is created, organised, and transmitted. The interview questions asked participants about the demands of forensic science practice and the knowledge and competencies needed to meet such demands. Each interview also provided an opportunity for each of the participants to consider the identity of forensic science and the impact of such identity on forensic science education.

The research methodology started with the document analysis which generated understandings about the current status of forensic science education through an investigation of the curricula of 190 forensic science academic programs offered worldwide. Document analysis identified ‘grey areas’ in forensic science knowledge, practice, and identity which required further investigation and clarification. The findings of the document analysis guided the second phase of the research methodology: semi-structured interviews. In the second phase of the methodology, the perceptions, informed opinions, and understandings of 14 interviewees (forensic science educators, practitioners, and members of associated professions) were transcribed and coded. Coded data was analysed to generate themes relating to forensic science knowledge, practice, and identity.

Finally, cross-comparative analysis was conducted across the themes generated by the document analysis and those identified by semi-structured interviews. This cross-comparative analysis generated insights into the nature of forensic science and recommendations about how to best organise and develop forensic science education.

This chapter has detailed the methodology employed in the study and the reasons behind employing it. The findings from this process in relation to document analysis are presented in Chapter 4. The findings from this process in relation to the conceptions of forensic science knowledge, practice, and identity are respectively reported in Chapters 5, 6, and 7. Discussions and final analyses about the nature of forensic science are presented in Chapter 8. Discussions about forensic science education and the research's recommendations are detailed in Chapter 9.

Chapter 4: Document Analysis

4.1- Introduction

Document analysis constituted the first phase of the research methodology. The idea behind the adoption of document analysis as one of the components of the research methodology emerged from:

- The fact that little is known or published about forensic science education (Houck, 2006; Mennell, 2006).
- The results of the initial typology reported in chapter1, where the typology sought to generate a preliminary sense of the current status of forensic science education within academia by considering the published curricula of 16 forensic science courses/programs offered worldwide.

The preliminary findings of the typology revealed that forensic science education is an undefined field. The typology suggested that the considered forensic science courses possessed no clear pattern(s) of: (1) what a course title might be, (2) the level of offer at which the course shall start, (3) the identity of the administering department, (4) the disciplines essential to be incorporated in the syllabus of the course, (5) and the place and extent of forensic science practice within the curriculum. These results have strongly suggested that further investigation needs to be undertaken to develop a deeper and more detailed understanding of the current status of forensic science education and the various curricular approaches organising and delivering such education. These preliminary, yet critical, implications revealed strong reasons for extending the typology of a few academic forensic science programs to an extended document analysis of forensic science programs offered worldwide. This extension will give the opportunity of: 1) developing the preliminary implications- previously revealed by the typology- into major implications and findings, 2) guiding the second phase of the research methodology: semi-structured interviews, and 3) creating a landscape for cross-comparison and analysis between the findings of the document analysis and those of the semi-structured interviews in order to generate final implications and recommendations.

4.2- List of the Participating Programs

The document analysis commenced with a list of 190 worldwide education institutes offering forensic science academic programs. These programs were found to incorporate one or more forensic science courses. For instance, a number of universities offered forensic science as single courses within science departments, whilst other universities offered forensic programs which comprised 2 or more forensic science courses. Hence, throughout this chapter, the term ‘programs’ refers to forensic science academic programs which included one or more forensic science courses.

This list of 190 forensic science programs (Table-4a; attached Appendix I) was formed following an inspection of various sources which provided information about institutes offering forensic science education. These sources are as follows:

- The American Academy of Forensic Sciences (AAFS) [Electronic[33]]
- Training programs offering forensic science (Camenson, 2001: 136)
- A Selection of institutions offering programs with forensic interest (Genge, 2002: 294)
- The National Institute of Forensic Science (NIFS) [Electronic[34]]
- Reddy’s Forensic website [Electronic[35]]

[33] http://www.aafs.org/default.asp?section_id=resources&page_id=colleges_and_universities, Accessed: 02/06/06.

[34] http://www.nifs.com.au/F_S_A/FSA_frame.html?Courses.asp&1, Accessed: 02/06/06.

[35] http://www.forensicpage.com/new07.htm, Accessed:07/06/06.

4.3- Selection Criteria

After the list of the 190 institutes offering forensic science programs had been established (Table-4a), a set of selection criteria was developed to enable the selection of programs for inclusion in the final analysis. The selection criteria were established to ensure that the final 15 forensic science programs examined in the document analysis were:

1. Identified as ‘forensic’ science programs and fell within the research’s working definition of forensic science (criminalistics).
2. Offered in native English-speaking countries which share the same British Common Law heritage on both the legislative and judicial levels. This selection condition was informed by the fact that forensic science is about science that pertains to law. Hence, the selection of forensic programs offered by education institutes in countries whose legal systems are similar made the analysis of the curricula of those programs less complicated.
3. Information-rich in course descriptions which allowed assessments of possible conceptual implication(s) of the programs’ curricular and pedagogical attributes of knowledge, practice, and identity.
4. Representative of the various academic institutions offering these programs worldwide.
5. Representative of all levels of offers: non-award degrees, undergraduate, postgraduate and both undergraduate and postgraduate.
6. Representative of the Australian forensic science programs as the research was conducted in Australia and the semi-structured interviews were undertaken with Australian interviewees.

To achieve these aims, the selection criteria were applied to the list of 190 forensic science programs across three stages: exclusion-based criterion, representative classification criterion, and points-based criterion.

4.3.1- The First Stage of Selection: Exclusion-Based Criterion

The first stage of selection was based on the method of exclusion-based criterion, where the 190 listed forensic science programs were examined against 5 exclusion factors. These exclusion factors were:

a. The program was offered in a non- native-English-speaking country whose legislative system held no connections with the British Common Law.

b. The website of the program was not available (i.e. URL address cannot be located).

c. The program did not fall within the research's working definition of 'forensic science'. For example, programs offering courses in forensic anthropology, archaeology, and psychology were omitted.

d. The program's outline was not an information-rich one. This was determined by the lack of:

- Content description (subject description) for both undergraduate degrees and postgraduate degrees by course-work.
- Research aim and significance for postgraduate degrees by research.

e. The program's outline did not emphasise its aim(s)/objective(s) and possible career opportunities upon graduation.

It was enough for a program to fall under one of the exclusion factors (a, b, c, d, or e) to be excluded from the list of the programs which were nominated for the second and third stages of the selection criteria. The exclusion-based criterion ensured that any program which passed its exclusion factors and, as a consequence, was nominated to the second stage of selection, at least enjoyed all of the following characteristics:

- It fell within the research's working definition of 'forensic science'.
- It was offered in a native English-speaking country which had a legislative system that followed or was connected to the British Common Law.
- Its outline was detailed with respect to content description.
- Its outline emphasised its aims/ objectives and possible career opportunities.

Prior to applying the exclusion-based criterion, the list of the 190 forensic science programs (Table- 4a in Appendix I) were randomly coded in order to keep the identity of the institutes offering such programs anonymous. Each of the 190 programs was assigned a code which started with the first three letters of the word "forensic" and ended with three random digits. The code of each program had the general form of: 'FOR # # #', where each of the '#' symbols was replaced by a digit. This anonymous coding process complied with the research code of ethics, set by Victoria University. The complete table (Table- 4b) which shows the implementation of the exclusion-based criterion on all 190 forensic science programs is attached at Appendix I. Following is a sample table showing the implementation of this selection criterion on a number of forensic science programs.

Sample Table of the Exclusion-Based Criterion						
Program Code	**Exc-a**	**Exc-b**	**Exc-c**	**Exc-d**	**Exc-e**	**Result**
FOR-650	1*	1	1	0•	–	**Excluded**
FOR-651	1	1	0	–	–	**Excluded**
FOR-654	1	1	1	1	1	**Passed**
FOR-660	1	1	1	1	1	**Passed**
FOR-552	1	1	1	1	0	**Excluded**
FOR-458	1	1	1	1	1	**Passed**
FOR-306	1	1	1	1	1	**Passed**
FOR-704	0	–	–	–	–	**Excluded**
FOR-758	1	1	1	1	1	**Passed**
FOR-850	**1**	**0**	–	–	–	**Excluded**

Sample Table-4b

* Pro-numeral 1 represents when course/ program passed the exclusion factor

• Pro-numeral 0 represents when course/ program fell under the exclusion factor, and hence was excluded.

After applying the exclusion-based criterion on the 190 listed forensic science programs, the following results were obtained (Table-4c):

<table>
<tr><th colspan="2">The Outcome of the Implementation of the Exclusion-Based Criterion</th></tr>
<tr><th>Excluded Programs</th><th>Passed Programs</th></tr>
<tr><td>112 programs were excluded for the following reasons:

• 49 programs fell under exclusion factor: a, b, or c.

• 63 programs fell under exclusion factor: d or e.</td><td>78 programs passed the exclusion process as these programs:

• were offered in English speaking countries,
• possessed valid website addresses,
• fell within the research's definition of forensic science,
• provided detailed content description,
• emphasised their aims/objectives and potential career opportunities.</td></tr>
</table>

Table-4c

The 78 programs which were nominated for the second stage of the selection criteria are listed in Table-4d.

List of the 78 Forensic Science Programs Nominated for the Second Stage of the Selection Criteria: Representative Classification Criterion.								
FOR-654	FOR-308	FOR-257	FOR-362	FOR-558	FOR-762	FOR-301	FOR-251	FOR-307
FOR-660	FOR-309	FOR-264	FOR-363	FOR-559	FOR-763	FOR-354	FOR-550	FOR-256
FOR-451	FOR-316	FOR-266	FOR-364	FOR-560	FOR-765	FOR-755	FOR-775	FOR-360
FOR-453	FOR-325	FOR-273	FOR-365	FOR-561	FOR-766	FOR-302	FOR-252	FOR-556
FOR-456	FOR-326	FOR-276	FOR-370	FOR-705	FOR-767	FOR-356	FOR-551	FOR-759
FOR-458	FOR-327	FOR-277	FOR-371	FOR-706	FOR-769	FOR-757	FOR-804	FOR-851
FOR-459	FOR-328	FOR-351	FOR-374	FOR-709	FOR-771	FOR-306	FOR-255	FOR-805
FOR-465	FOR-330	FOR-352	FOR-375	FOR-715	FOR-773	FOR-358	FOR-554	FOR-758
FOR-468	FOR-250	FOR-353	FOR-377	FOR-754	FOR-774			

Table-4d

4.3.2- The Second Stage of Selection: Representative Classification Criterion

In this stage, the 78 programs which passed the first stage of the selection criteria (exclusion-based criterion) were categorised into 5 groups ranked I, II, III, IV & V. Categorization into 5 groups was conducted according to the level of academic offer of the course(s) included in each of the 78 programs:

- Group I: Programs leading to non-awards degrees in forensic science (e.g. Certificates, Diplomas, and Associate Degrees).

- Group II: Programs leading to minor degrees in forensic science associated with major undergraduate degrees (e.g. a bachelor degree in a major discipline such as chemistry, whilst offering forensic science as a minor degree, option, or emphasis).

- Group III: Programs leading to major undergraduate degrees in forensic science (e.g. BSc in forensic science, BA in forensic science, Bachelor of Technology in forensic science, etc).

- Group IV: Programs leading to postgraduate degrees in forensic science (e.g. Postgraduate diplomas and Master's in forensic science).

- Group V: Programs offering both undergraduate and postgraduate degrees in forensic science.

In addition to categorising each of the 78 selected programs into one of five specific groups (Groups I-V), the titles of the administering department of each program were noted next to this program as presented by sample Table-4e (The complete table: Table-4e is attached at Appendix I). The purpose behind such categorising and classification was to assist in the generation of some descriptive statistics.

Sample Table of the Categorisation and Classification of the 78 Passed Programs		
Program Code	Categorizing Group	Administering Department
FOR-654	I	Administration of Justice Program
FOR-660	II	Department of Sociology and Criminal Justice
FOR-451	IV	Multi-Departmental Course
FOR-458	II	Department of Chemistry
FOR-306	III	Department of Criminal Justice
FOR-325	III	College of Science and Mathematics
FOR-715	III	Department of Chemical and Forensic Science
FOR-758	III	School of Biological Science and Biotechnology
FOR-763	V	Department of Laboratory and Forensic Science
FOR-773	III	Faculty of Science and Information of Technology
FOR-805	III	Inter-Faculty Program

Sample Table-4e

Prior to proceeding to the third stage of the selection criteria, statistical analysis was conducted on the data presented in Table-4e (Appendix I). Statistical analysis generated two bar charts. The first chart (Figure-4a) represents the distribution of the 78 selected forensic science programs with respect to administering departments. The second chart (Figure-4b) represents the distribution of those programs with respect to their academic level of offer.

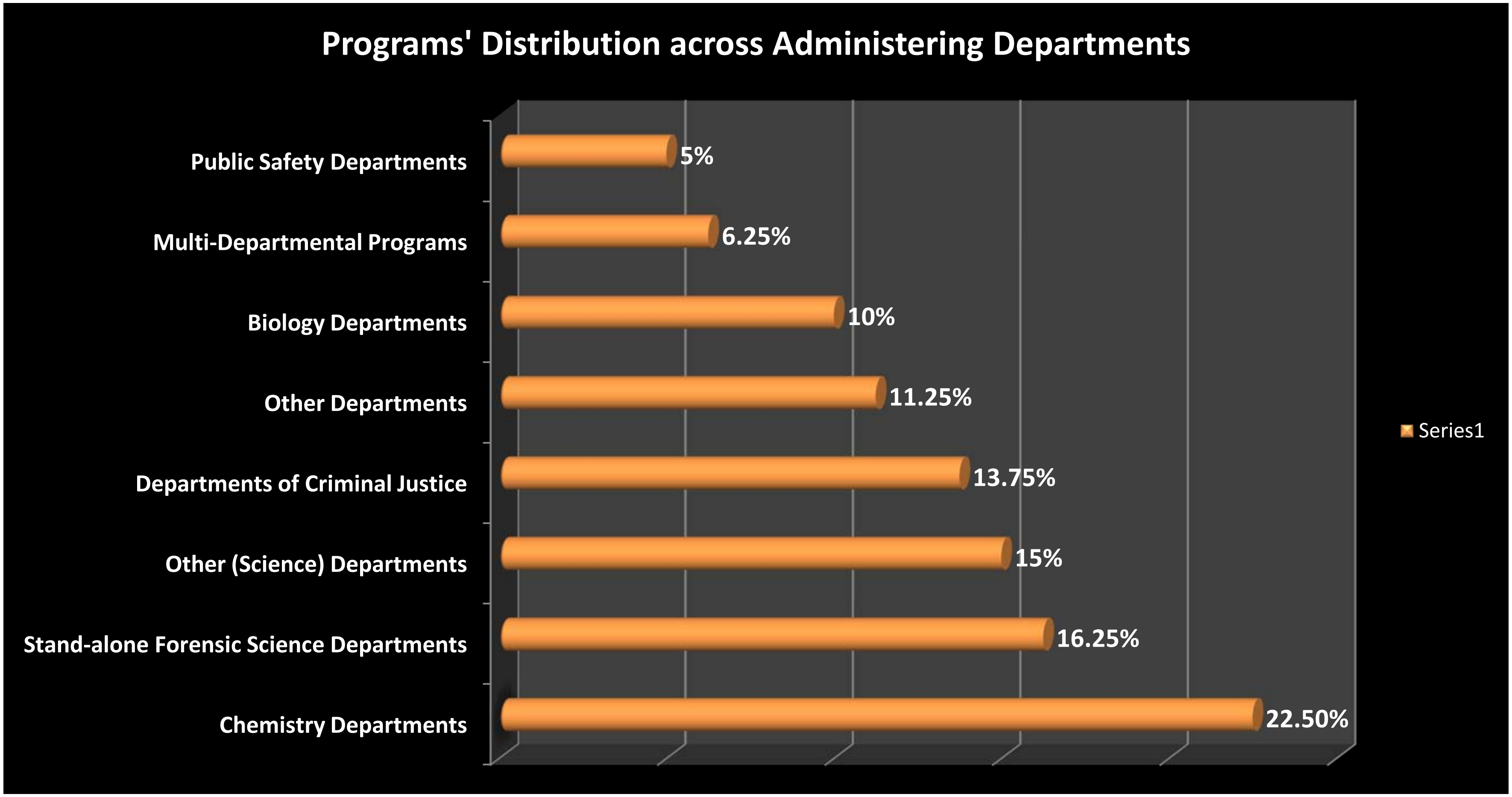

Programs' Distribution across Administering Departments
Public Safety Departments
5%
Multi-Departmental Programs
6.25%
Biology Departments
10%
Other Departments
11.25%
Departments of Criminal Justice
13.75%
Other (Science) Departments
15%
Stand-alone Forensic Science Departments
16.25%
Chemistry Departments
22.50%
Series1

Figure-4a

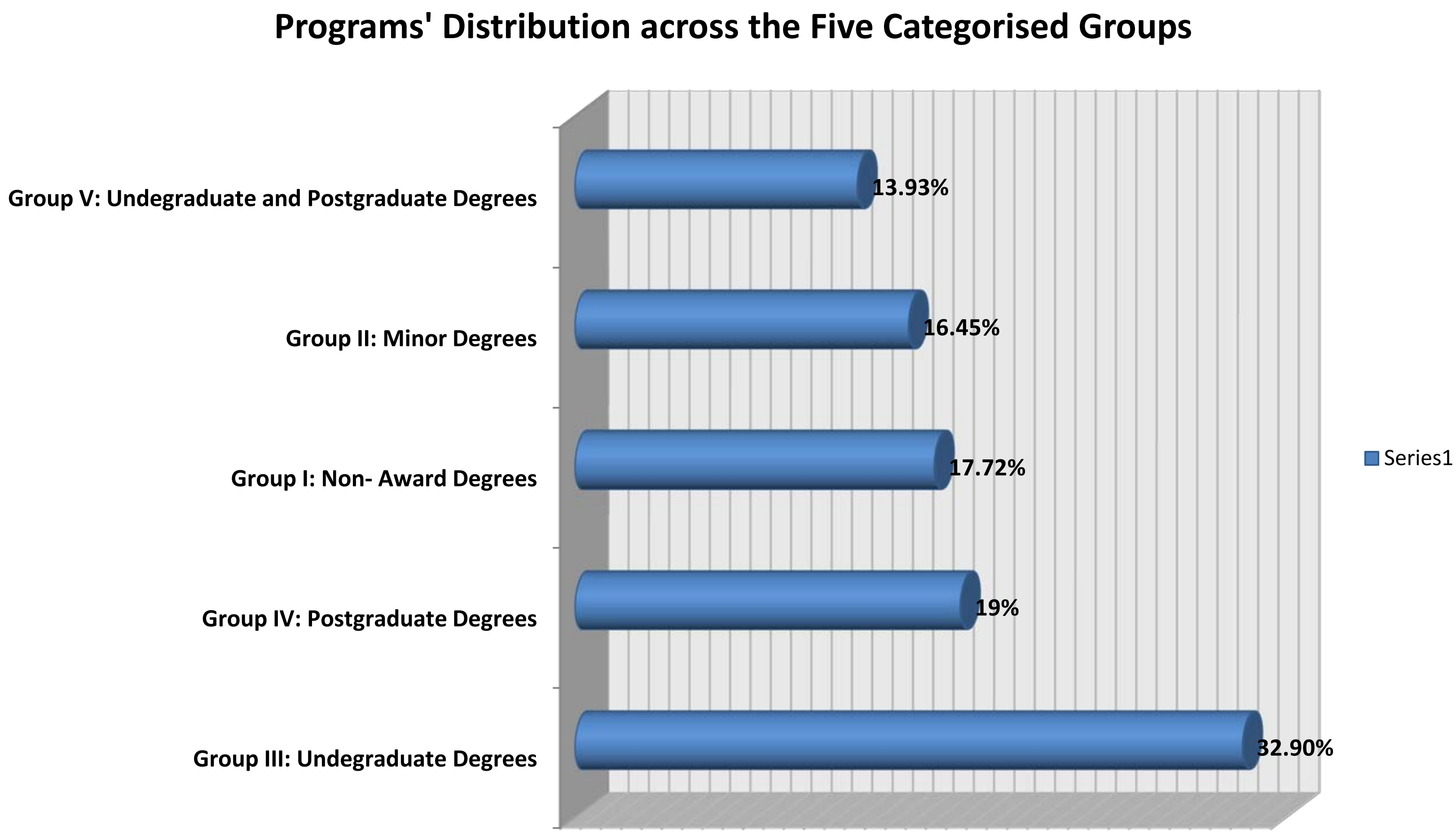

Programs' Distribution across the Five Categorised Groups
Group V: Undegraduate and Postgraduate Degrees
13.93%
Group II: Minor Degrees
16.45%
Group I: Non- Award Degrees
17.72%
Group IV: Postgraduate Degrees
19%
Group III: Undegraduate Degrees
32.90%
Series1

Figure-4b

This limited quantitative analysis contributed to the final discussions of the document analysis and was used in the next phase of the methodology (semi-structured interviews), where interviewees were invited to comment on these two charts.

Following the classification of the 78 selected programs into 5 categorising groups (Table-4e) and running statistical analyses, a final set of 15 programs was selected for the thorough and detailed analysis. The number 15 was not arbitrarily chosen. It was statistically essential to include at least 15.7% of the 78 passed programs (equivalent to at least 13 out of the 78 programs) in the final analysis for this analysis to be significant at 95% confidence level (Sirkin, 2006). Hence, the selection of a final set of 15 programs for the final analysis was both statistically significant and representative of the 78 forensic science programs.

Prior to the selection of the final set of programs, the number of the programs which fell under each of the 5 categorising groups (Groups I, II, III, IV, and V) were counted and reported as a fraction of the total 78 programs. These fractions were then converted into a percentage which is termed the weighted representative percentage (WRP). The WRP was used to determine the number of programs to be selected from each of the 5 categorising groups to constitute the final set of 15 programs. In other words, the higher the WRP of a certain group, the more this group was represented in the final set of programs and vice versa. It is to be noted that when an educational provider categorised in more than one group, it was automatically considered for the group of higher numerical rank. The results of this process are presented in Table-4f

RESULTS	**Group I**	**Group II**	**Group III**	**Group IV**	**Group V**	**Total**
Distribution of programs over the 5 Groups	**14/78**	**13/78**	**25/78**	**15/78**	**11/78**	**78**
Weighted Representative Percentage (WRP)	**18%**	**16.50%**	**32.00%**	**19.00%**	**14.5%**	**100%**
Number of programs representing each Group	**3**	**2**	**5**	**3**	**2**	**15**

Table-4f

4.3.3- The Third Stage of the Selection: Points- Based Criterion

After the completion of the second stage of the selection criteria (representative classification criterion), it was evident that the final set of programs had to be selected in the following proportions:

Group I		Group II		Group III		Group IV		Group V
3	**:**	**2**	**:**	**5**	**:**	**3**	**:**	**2**

To facilitate the selection of the final set of 15 programs from the nominated list of the 78 programs which passed the first and second stages of the selection process, a 10-point evaluation scale was implemented. The 10-point evaluation scale facilitated the selection of the final set of 15 programs which:

- complied with the main aims of the selection criteria: (1) fell under the research working definition of 'forensic science', (2) were offered in a native English-speaking country, (3) were detailed with respect to content description, aims/objectives, and potential career opportunities, (4) were representative of all levels of academic offer, and (5) were representative of the Australian institutes offering forensic science.

- offered additional insights on the programs' prerequisites, adopted curricular approaches, adopted pedagogical strategies, place and extent of practice within the adopted curricula, and relationship to external authorities.

The 10 points of the evaluation scale were distributed over the following features/characteristics:

- provided by an Australian institute (1 pt)
- indication of course prerequisites (1 pt)
- indication of any curricular integration (1 pt)
- emphasis of any relationship to external authorities (1 pt)
- indication of teaching methods (1 pt)

- emphasis of assessment practices (1 pt)
- indication of any practitioner participation in course delivery (1pt)
- overall rating of program: the extent the syllabus was detailed, aims/ objectives were developed, and specific career opportunities were addressed (3 pts)

The 10-points evaluation scale was applied over the 78 programs as presented in sample Table-4g (Complete Table-4g is attached at Appendix I).

Sample Table Representing the Implementation of the Point-Based Criterion										
Program Code	**Group**	**PB_1[36]**	**PB_2[37]**	**PB_3[38]**	**PB_4[39]**	**PB_5[40]**	**PB_6[41]**	**PB_7[42]**	**PB_8[43]**	**Total /10**
FOR-654	I	0	0	0	0.5	1	0	0	2.5	4
FOR-660	II	0	0	1	1	0	0	1	2.5	5.5
FOR-451	IV	0	1	1	1	0	0	1	3	7
FOR-458	II	0	0	0	1	0	1	0	3	5
FOR-306	III	0	1	1	0.5	0	0	0	3	5.5
FOR-325	III	0	0	0	1	0	0	1	1.5	3.5
FOR-715	III	0	1	1	0	1	1	1	3	8
FOR-758	III	1	0	0	1	0	0	0	3	5
FOR-763	V	1	1	1	1	1	0	1	2	8
FOR-773	III	1	1	0	0	1	0	0	3	6

Sample Table-4g

[36] PB_1 = 1pt for Australian provider

[37] PB_2 = 1pt for course prerequisite(s)

[38] PB_3 = 1pt for curriculum disciplinary implications

[39] PB_4 = 1pt for relationship to external authorities

[40] PB_5 = 1pt for indication of teaching methods

[41] PB_6 = 1pt for assessment practices

[42] PB_7= 1pt for practitioner participation in course delivery

[43] PB_8 = 3pts for overall rating of course (subjects' description, course aims/objectives, and potential career opportunities).

Following the application of the 10 point-based criterion, the total number of points that each program achieved was reported and final selection was processed as follows:

1. The highest 3 ranking programs of Group I were selected.
2. The highest 2 ranking programs of Group II were selected.
3. The highest 5 ranking programs of Group III were selected.
4. The highest 3 ranking programs of Group IV were selected.
5. The highest 2 ranking programs of Group V were selected.

It is to be noted that when more than the required number of programs in a group were equally ranked, then these programs were cross-compared. Those programs with more detailed information about the adopted curricular and pedagogical approaches were favoured over the others. Table-4h presents the 15 final selected programs which were considered in the detailed document analysis.

List of the set of the 15 Final Selected Forensic Science Programs	
Group I (3 programs)	**FOR-276, FOR-375 & FOR-358**
Group II (2 programs)	**FOR-560 & FOR-551**
Group III (5 programs)	**FOR-715, FOR-558, FOR-766, FOR-709 & FOR-754**
Group IV (3 programs)	**FOR-762, FOR-554 & FOR-556**
Group V (2 programs)	**FOR-706 &FOR-757**

Table-4h

4.4- Data Coding

Data collected from the final set of 15 forensic programs were then coded according to a coding framework (Appendix C). This framework emphasised the conceptual attributes which might be revealed by the published curriculum of the course(s) incorporated within these programs. These attributes related to:

a. The nature of forensic science knowledge
   - Curriculum nature and organisation,
   - Knowledge fields in course,
   - Teaching pedagogies and curricular activities adopted in course delivery,
   - Assessment practices, and
   - Connections between knowledge fields and curriculum components

b. The nature of practice emphasised
   - Place of forensic practice in course,
   - Extent of practice,
   - Pedagogical practice, and
   - Practitioner participation in course delivery

c. Identity possessed:
   - Course location,
   - Course type,
   - Relation to other courses,
   - Evidence of course outcomes, and
   - Relationship to external authorities

Coding of the data collected from each of the final 15 selected programs is presented in Appendix J. The following sample chart presents coding for one of the final selected programs (FOR-558).

Data Coding Sample Chart- Group III/ Program Code: FOR-558

KNOWLEDGE

a. Curriculum nature and organisation

The curriculum includes: general education subjects, forensics core subjects, and specialisation subjects. Program offers 4 major concentrations: crime scene investigation, fire and arson investigation, forensic science, and forensic pathology. The program follows an interdisciplinary approach.

b. Knowledge fields in course

Course Structure[44]: F 21, C 5, B 4, M 1, L 2, and O 10.

c. Teaching approaches and curricular activities adopted in course delivery

Program is delivered through classroom instruction and interaction, hands-on laboratory skills, and practicum experience.

d. Connections between knowledge fields and curriculum components:

This program aims to offer students:

-Scientific methodology, divergent problem solving strategies, critical thinking, problem-based setting framed by forensics, and basic investigative skills that prepare them for entrance into a career as an investigator and/or crime scene technician.

-Competencies and specialised skills to recognize, properly document, collect, preserve, identify and examine forensic evidence.

The course approaches its aims through integrating chemistry, natural sciences, and criminal justice under a heavy forensic concentration (e.g. fingerprinting, crime scene, etc) in an interdisciplinary course. It offers students on campus learning (problem based settings such as. mock-up homicide scenes and moot court lab), conference attendance, close-knit group (student with same uniform and forensic badge), cold cases study, and actual field experience (senior students called up to attend and assist law enforcement officers in real crime scenes e.g. diagramming and photographing).

PRACTICE

a. Place of forensic practice in course:

Within university and in collaboration with local enforcement agencies.

b. Extent of practice:

Laboratory, mock crime scenes, and practicum experience through re-study and re-analysis of real cold cases with local enforcement agencies.

c. Pedagogical practice:

The program emphasises hands-on training, crime scene processing competencies (recognition, documentation, collection, preservation, identification and examination of evidence), and specialised skills in crime investigation (drugs, homicide, sex offences, etc). Program offers opportunities to learn craft- from grave digs to mock-ups of homicide scene. Program offers senior level students to work with local enforcement agencies on cold cases that are 5-30 years old.

d. Practitioner participation in course delivery:

Local enforcement practitioners work with students on studying, analysing and commenting on cold cases.

IDENTITY

a. Course Type:

Major Undergraduate- Group III

b. Course Location:

Administering department: school of arts and sciences

c. Relation to other courses:

Stand- Alone Course

d. Evidence of course outcomes:

Career opportunities that the program reveals are state and federal forensic jobs (U.S.A) including: crime scene investigator, fingerprint technician, photographer, evidence technicians, homicide investigator, food and drug inspector.

e. Relationship to external authorities:

Relation to local enforcement agencies.

f. Other attribute(s) to identity:

-Forensics is a young science and profession; however, it is a dynamic one and growing field that is spurred by new technologies, increased use by law enforcement, jury expectations, and new legal requirements.

-The popularity of forensics-related TV shows, along with great prospects for employment, makes this a popular major.

- Program suggests that up to 10,000 jobs will be available in forensic science in the next 10 years.

- Program offers 4 major concentrations.

[44] F 21= 21 Forensic Subjects, C 5= 5 Chemistry Subjects, B 4= 4 Biology Subjects, M 1= 1 Mathematics Subject , L 2= 2 Law Subjects, O 10= 10 Other Subjects (e.g. English, Communication, …)

4.5- Data Analysis and Implications

Following the coding of the conceptual attributes emphasised by each of the final 15 selected programs (Appendix J), the following knowledge, practice, and identity conceptual attributes were identified:

4.5.1- Knowledge Conceptual Attributes

Document analysis identified 11 knowledge conceptual attributes through examining the course(s) comprising each of the final 15 selected programs. Examination focused on the curriculum nature and organisation, the knowledge fields incorporated in the course, teaching pedagogies adopted in course delivery, and assessment practices. Any reported connections between knowledge fields and curriculum components were considered as well. The identified knowledge conceptual attributes are as follows:

1. Forensic science incorporates pure sciences (mainly chemistry and biology), derived sciences (e.g. biochemistry, biophysics), law, and uniquely forensic forms of inquiry such as crime scene investigation, fingerprint examination, and tool mark examination (e.g. FOR-551, FOR-715, FOR-558, FOR-766, FOR-754, and FOR-706).

2. The curricular approaches adopted by the courses of the selected programs fell within Bernstein's two broad curriculum categories: 'collection-code type curriculum' and 'integrated-code type curriculum' (Bernstein, 1977). The two identified major curricular approaches were:
   a. The multidisciplinary approach (collection-code curriculum) which allows cross-disciplinary interaction between different disciplines. However, it keeps subjects' content distinct and finally uses the methods of one discipline in its examination. For example, both FOR-551 and FOR-766 courses incorporated a heavy chemistry component. These two courses followed a multidisciplinary

curricular approach which assisted the students in understanding and exploring the forensic science nature by drawing upon various disciplines (e.g. chemistry, biology, mathematics, physics, law, etc). However, the students ultimately used methods and techniques from chemistry to examine and study forensic science. The various subjects included in the curriculum of these two courses (e.g. chemistry, biology, mathematics, law, etc) remained separated from one another; i.e. the boundaries between various subjects were maintained.

b. The interdisciplinary approach (integrated-code curriculum) which allows the integration of two or more disciplines in pursuit of a common topic: forensic science in such case. For example, both FOR-276 and FOR-558 courses adopted interdisciplinary approaches where they integrated chemistry, biology, mathematics, physics, law, and uniquely forensic forms of inquiry (e.g. fingerprinting, tool mark examination, etc) in subjects such as "crime scene investigation", "physical evidence", and "forensic science cases". Such integration served the one major guiding idea: science pertaining to law. It is to be noted that in these two courses (FOR-276 and FOR-558) boundaries between disciplines were more blurred than those in courses following the multidisciplinary approach.

These two major identified curricular approaches: multidisciplinary and interdisciplinary respectively existed in an approximate 1:2 ratio among the final selected courses. In addition, the following patterns were noted among these courses:

- The majority of the courses adopting the multidisciplinary approach (5 of 6) used chemistry as the major discipline to examine and study forensic science.

- One of group III programs (FOR-715) adopted a curricular approach which started as a collection-code type curriculum in the first 2 years and ended up as an integrated-code type curriculum in the third year. This program emphasised 'education in depth' in the first two years where the student studied core science subjects. Then in the third year, the program emphasised 'education in breadth’ where the students identified and solved complex forensic science problems through integrating acquired knowledge and skills.

- One of the group III programs (FOR-709) implemented both the interdisciplinary and multidisciplinary curricular approaches. This program adopted a multidisciplinary approach when offering BSc in forensic chemistry and BSc in forensic biology, where the major examining discipline is chemistry in the first and biology in the second. The program adopted an interdisciplinary approach when offering BSc in forensic science, where the course integrated under the forensic science heading all of chemistry, biology, maths, law, and uniquely forensic forms of inquiry.

- All group IV programs adopted the interdisciplinary curricular approach. These programs emphasised that after students had covered ‘education in depth’ in pure sciences at the undergraduate level, they were required to cover ‘education in breadth’ in the various forensic science specialisations via adopting interdisciplinarity.

3. Group I courses (e.g. FOR-276 and FOR-358) are non-award programs where education is vocational in nature. The curriculum of these courses generally incorporated: a) a large component of vocational forensic science subjects (e.g. photography, crime scene processing & investigation, sample collection, and questioned documents examination), b) a moderate law component and c) a light science component (e.g. chemistry and biology) as opposed to the heavy science component that emphasised within the other groups (Group II, III, IV, & V). Group I courses catered to:
    - Current law enforcement personnel (e.g. police members, private investigators, and personnel licensed in various security and investigative areas) who wished to join or change over to the forensic area or acquire general and basic education in the forensic science field.

- Current forensic field practitioners (e.g. crime scene investigators) mainly with basic or general educational background (e.g. early school leavers) who enrolled in these programs to either fulfil a job training requirement or seek a promotion.

- Students who are interested in forensic science as a field of knowledge or who seek a junior entry level within the forensic science field.

Whilst Group I courses did not go into an in-depth treatment of the scientific principles and theories underpinning forensic science techniques (e.g. analytical chemistry and molecular biology), the majority of Groups II, III, IV, & V courses incorporated a heavier and more specialised science component. Such courses were mainly directed towards students aiming for job opportunities as forensic scientists.

4. Group II courses are those which offered forensic science as a minor degree or as an option/emphasis within a major science degree. These courses are mainly chemistry oriented. Hence, they incorporated a heavy chemistry component with an appreciation of biology in response to the developments of molecular biology technologies (DNA profiling) within the forensic investigation. Law subjects were also appreciated within the curriculum of these courses although the extent of such appreciation varied from one course to the other. These courses also emphasised public speaking subjects which trained students to present their reports in public. It is noticed that the curriculum of Group II courses incorporated a light forensic science component, where the emphasised science subjects (chemistry and biology) greatly exceeded the forensic science subjects (FOR-551 and FOR-560).

   Group II courses aimed to graduate students with strong science- particularly chemistry- backgrounds for two reasons: 1) graduates with a degree based in chemistry possessed one of the most sought-after backgrounds in criminalistics (FOR-560); 2) graduates with a strong science background had alternative employment opportunities as specialised scientists (FOR-551 and FOR-560).

5. Group III programs (e.g. FOR-715, FOR-558, and FOR-709) are mainly undergraduate bachelor degrees in forensic science, where the graduates of such courses were identified as forensic science graduates. In addition to the forensic science component, these courses offered either:

    - a major heavy science component (e.g. chemistry) in a multidisciplinary approach where graduates were both identified as forensic science graduates and accredited by the relevant scientific bodies related to the course's major science component (e.g. forensic chemistry graduates were also accredited as chemists by their national chemistry associations). Potential career opportunities mainly fell within laboratory positions in forensic science agencies and within professional positions requiring science specialisations (e.g. chemists).

    - a combination of several science and law subjects (chemistry, biology, maths, physics and law) in an interdisciplinary approach where graduates were identified as forensic science graduates and potential career opportunities mainly fell within field positions in forensic science agencies and within police departments.

    Group III courses aimed to provide students with scientific methodology and to develop students' critical thinking and to promote their problem-solving competencies. These courses stressed the importance of communication skills (written and oral skills) to enable the presentation of scientific information to a range of recipients (public, jury, judges, barristers, etc).

6. Group IV programs (e.g. FOR-762 and FOR-554) are postgraduate programs which assumed that students attending these courses had already covered fundamental scientific components in their undergraduate studies. Hence, these courses emphasised a more specialist interdisciplinary approach which integrated various disciplines in order to develop analytical and problem-solving skills in conducting specialised forensic tasks (e.g. drug testing and trace evidence). Courses falling

within this group were either offered through course-work, research or a combination of both approaches.

7. Group V programs (FOR-706 and FOR-757) are those which offered both undergraduate and postgraduate courses in forensic science. These courses offered various specialisations. Students who finished undergraduate degrees within such programs had the opportunity to extend their studies by enrolling in a postgraduate degree with the same provider. It is to be noted that at the postgraduate level, it is common to see Master of Science degrees in forensic science with a specific area of emphasis (e.g. DNA profiling, document analysis, criminalistics, etc). However, it is highly uncommon to see a doctorate degree in forensic science, for such level of academic study is usually offered within a major science discipline (e.g. PhD in chemistry, biology, biotechnology, physics, etc) where the research topic is focused on an area of interest to forensic science.

8. The pedagogies adopted in knowledge transfer between academics and students were emphasised through one or more of these formats:
    - Traditional lecture-based learning
    - Experimental-based learning through laboratory classes
    - Problem-based learning through working on mock-up crime scene and moot court presentations.
    - Practice-based learning in collaboration with a supervisor from a forensic science centre or a law enforcement agency
    - Self-directed learning
    - Seminars
    - tutorials
    - Workshops
    - Conferences

It is to be noted that pedagogies such as problem-based learning were more emphasised within courses adopting interdisciplinary curricular approach (e.g. FOR-558 and FOR-715).

9. The majority of the programs (e.g. FOR-560, FOR-715, and FOR-558) emphasised the need for graduates to show, at the end of the course, appropriate levels of understanding of the legal system.

10. A number of courses stressed the need for students to show capabilities such as critical thinking (e.g. FOR-715 and FOR-558) and proficient communication skills (e.g. FOR-560 FOR-766) upon graduation.

11. The majority of courses (e.g. FOR-754, FOR-551, FOR-757, and FOR-766) asserted that a science degree is a prerequisite for practicing at any forensic laboratory.

4.5.1.1- Summary of Knowledge Conceptual Attributes

Forensic science is an emerging field which incorporates pure sciences, derived sciences, law, and vocational forensic applications. The two major curricular approaches revealed by document analysis were the multidisciplinary and interdisciplinary models. The multidisciplinary-type curriculum kept subjects' content distinct and finally used the methods of one discipline (often chemistry or biology) in its examination. On the other hand, the interdisciplinary-type curriculum integrated two or more disciplines under the one forensic science heading, where boundaries between various subjects were more blurred than those in the multidisciplinary model. The final set of the selected forensic science programs categorised into 5 groups:

- Group-I courses are non-award programs characterised by vocational education. These courses target currently employed law enforcement personnel as potential students.

- Group-II courses are those which offer forensic science as a minor degree or as an option within a major science degree. These courses were mainly chemistry centred.
- Group-III courses are undergraduate courses in forensic science, where the graduates of such courses were identified as forensic science graduates.
- Group IV courses are postgraduate courses following a specialised interdisciplinary approach which integrated various disciplines within the one curriculum.
- Group V courses are those which offered both undergraduate and postgraduate courses in forensic science of various specialisations.

The pedagogies adopted in knowledge transfer were mainly emphasised via various formats: a) traditional lecture-based learning, b) experimental-based learning through laboratory classes, c) problem-based learning, and/or d) practice-based learning.

4.5.2- Practice Conceptual Attributes

Document analysis identified 5 practice conceptual attributes through examining the course(s) comprising each of the 15 selected forensic programs for the place of forensic practice within these courses, the extent of such a practice, and practitioners' participation in course delivery. The identified conceptual practice attributes were as follows:

1. The nature of practice in forensic science is characteristic of the individual legislation and regulatory scheme adopted by each individual jurisdiction. For example, in a number of jurisdictions, police officers process crime scenes themselves, whilst forensic scientists are dedicated to laboratory work and are only called onto crime scenes when required. In other jurisdictions forensic scientists do both field and lab work (FOR-551). Another example is the nature of forensic practice in Germany, where medical practitioners attending crime scenes perform two roles: crime scene processing and forensic medical examination. These roles are clearly separated in other countries as in the U.K. and Australia (FOR-709). A

third example is the prerequisite set by a number of jurisdictions for applicants to forensic positions. A number of jurisdictions require that applicants to forensic positions be current members of the military or police force, whilst other jurisdictions allow civilians to apply for such positions (FOR-551).

2. The practice component within the selected programs was represented via different formats:
   - Only through laboratory work within the university (FOR-375 and FOR-757);
   - Through laboratory work, seminars, and visits to relevant agencies (FOR-560);
   - Through laboratory work, mock-up homicide scenes, moot courts, and practicum experience constituting the re-study and re-analysis of real cold cases (5-30 years old) with local enforcement agencies (FOR-558 and FOR-762);
   - Through both laboratory work within university and vocational training in collaboration with practicing crime laboratories or local enforcement agencies. This on-site practice was emphasised as a work placement extending to less than one year: several weeks, several months, or during summer quarter (FOR-551 and FOR-556);
   - Through both laboratory work within university and practice-based learning. Practice-based learning takes place through a one year internship within the forensic industry (FOR-715, FOR-766, FOR-554 and FOR-709);
   - Within the university with the option of extending the course's duration to one extra placement year within the forensic industry (FOR-754 and FOR-706).

3. Practitioners' contributions in course pedagogy were mainly emphasised in three forms:
   a. Major Contribution (67%): This contribution took place in courses where the majority of the subjects were taught by forensic practitioners or academics who were previously practitioners in the field. Learning also took place through the 1 year internship, during which students reported to both academic supervisors nominated by their administering departments and industrial supervisors nominated by their workplaces (e.g. FOR-706, FOR-358, and FOR-558). The major contribution of practitioners were also emphasised in

postgraduate research degrees where research students undertake their research supervised by both an academic from university and a practitioner in the field (e.g. FOR-554).

b. Specific-Subject Contribution (27%): This contribution occurred when practitioners taught/delivered specific subjects within the curriculum. Such subjects were often of an explicit forensic nature such as ‘crime scene investigation’, ‘fingerprint examination’, and ‘document examination’ (e.g. FOR-551 and FOR-766).

c. Minor Contribution (6%): This contribution took place when practitioners’ involvements in course delivery were limited to seminars, on-site explanations, mock-up homicide scenes, and/or moot court presentations (FOR-560).

The extent to which practitioners may contribute (major, specific-subject, associated, or not at all) seems to be strongly dependent on the links which exist between the university itself and the relevant law enforcement authorities. For instance, FOR-556 is offered within a university which houses a forensic DNA laboratory containing actual DNA profiles which are part of the national DNA database. This laboratory is both funded and accessed by state police and forensic science practitioners. Another example is FOR-558, where the coordinators of this course have a strong partnership with the local enforcement agency. Such partnership enabled senior forensic science students in this course to accompany forensic practitioners to real crime scenes and assist in some of the practical work (e.g. crime scene diagramming and photographing). Such links and partnerships might maximise the exposure of students to real practice settings and the contribution of forensic practitioners in course delivery.

4. The competencies that were emphasised by most of the selected courses through pedagogical practice comprised:
   - Critical thinking: developing and demonstrating critical thinking and interpretive skills through independent investigation of forensic topics and the

underlying sciences and the recognition of the uncertainty and limits of such investigation (e.g. FOR-276, FOR-715, and FOR-558).

- Problem-solving competencies: Identifying complex problems, applying appropriate knowledge and skills to the solutions of such problems (e.g. FOR-715, FOR-558, and FOR-706).
- Written and oral presentation skills: presenting scientific information and sustaining arguments clearly and correctly in writing and orally to a range of audiences such as to the general public, barristers, judges, jury, etc (e.g. FOR-709, FOR-762, and FOR-706).

5. Document analysis revealed that there is no consensus on whether a tertiary degree must be a prerequisite for employment within the forensic industry particularly in relation to field positions (e.g. crime scene investigation, motor vehicle examination, fingerprinting, etc). For example, in some countries, employment in the forensic science sector- particularly in field work- is open to police officers after undergoing an in-service training program (e.g. FOR-551 and FOR-754). On this issue, one of the courses (FOR-551) emphasised that the more the technical demands of evidence collection and documentation increase, the more the science educational requirements of crime scene investigators would accordingly increase.

   On the other hand, forensic laboratory positions (laboratory technicians, analysts, and researchers) do require a minimum of a bachelor's degree in a related science discipline (FOR-754).

4.5.2.1- Summary of Practice Conceptual Attributes

In summary, the nature of practice in forensic science is impacted by the individual jurisdiction under which forensic science operates. Such nature differentiates between field-work and laboratory-work. Whilst there is no consensus on the requirement of a tertiary degree for field work practice, there is consensus on the prerequisite of a tertiary degree for laboratory practice.

The practice component within the selected courses were emphasised through: 1) university laboratory practicals 2) mock-up homicide scenes, 3) moot court presentations, and 4) practice-based learning through work placements or internships. It is to be noted that 54% of the selected programs emphasised work placements or one year internships within their curricula.

In terms of their contribution to course pedagogy, practitioners made major contributions in 67% of the courses, specific-subject contributions in 27% of the courses, and minor contributions in 6% of the courses.

Practice-related competencies that were emphasised by most of the selected courses were critical thinking, problem-solving skills, and communication skills.

4.5.3- Identity Conceptual Attributes

Document analysis identified 9 conceptual attributes in relation to forensic science stature, image, profile and identity. These attributes were identified through examining the course(s) comprising each of final 15 selected programs for any indications of: course location, course type, evidence of course outcomes, and relationship to external authorities. Document analysis identified the following conceptual identity attributes:

1. Forensic science was emphasised as a dynamic young science and profession (FOR-558) of high profile (FOR-709) which is rapidly evolving and which receives substantial support for expansion (FOR-554).

2. Forensic science development in the last two decades has been impacted by:
   a) The evolution of new technologies in various fields of interest to forensic science such as molecular biology, analytical chemistry, and DNA profiling technologies (FOR-551),

   b) The increased use of forensic science by governments and law enforcement agencies (FOR-558),

c) The high media concentration which increased public awareness and scrutiny of forensic science (FOR-551, FOR-558, and FOR-706), and

d) The legislative guidelines and legal requirements set for handling and analysis of physical evidence, certification of crime labs, and admission of expert testimony by courts of law (FOR-766).

3. The statistical analysis, conducted on 78 forensic programs during the second stage of the selection criteria, revealed the following results in regard to the distribution of the courses across administering departments (Table-4i)

Distribution of Forensic Science Courses across Administering Departments	
Chemistry Departments	**23%**
Stand-alone Forensic Science Departments	**17%**
Other (Science)* Departments	**15%**
Departments of Criminal Justice	**13%**
Other• Departments	**11%**
Biology Departments	**10%**
Multi-Departmental Programs	**6%**
Public Safety Departments	**5%**

Table-4i

* Other (science) Departments incorporated schools of science, physical science departments, etc. i.e. this category comprised departments with a general science umbrella without emphasis on a dominating science discipline; This is why it was termed as other (science) departments

• Other Departments incorporated departments/divisions such as centre for health sciences, humanities & social sciences division, department of professional studies, etc.

This statistical analysis prompted the following implications:

- Departments of chemistry occupied the highest percentage among all administering departments (23%). Such percentage is not proportional with what has been revealed by the literature in this respect. The literature emphasises that chemistry is the major administering department of forensic science (Smallwood, 2002). The difference between what is emphasised by literature and what is revealed by the statistical analysis may be attributed to the migration of forensic science courses towards biological science departments and stand-alone forensic science departments at the expense of chemistry departments.

- Departments of criminal justice housed 13% of the courses in the sample. This is understandable due to the very strong liaison between forensic science, law, and criminal investigation. Forensic science is science pertaining to law. Hence, all the work done by the forensic scientists is dedicated to the judicial system.

- One of the notable results was the percentage (10%) occupied by the department of biological sciences. Document analysis revealed that in the past forensic science was mainly dependent, in performing the majority of its tasks, on chemistry (e.g. FOR-560 and FOR-709). However, during the last two decades forensic science dependence on biology to perform its tasks has steadily increased. This has occurred as a result of advances at the boundaries between disciplines (specifically chemistry and biology) which has increased human understanding of the biochemistry of living organisms, heredity, reproduction, DNA technology, and various issues in biology and molecular biology (e.g. FOR-709, FOR-551, and FOR-556). Such advances and increased understanding have led to a large scale adoption of bioscience techniques to collect and analyse forensic evidence. Hence, forensic investigation has become increasingly dependent on the techniques of forensic biology. As a result, a number of education providers added coursework in genetics and biology to the syllabus of their forensic science courses, whilst other providers organised the delivery of new forensic biology courses (e.g. FOR-556 and FOR-551). This justifies the notable percentage of forensic science courses administered by biology departments.

- 17% of the courses were housed within stand-alone forensic science departments. Document analysis revealed that most of the courses that were administered by stand-alone forensic science departments offered various specialisations within their forensic science programs such as forensic biology, forensic chemistry, and forensic science with a physics emphasis (e.g. FOR-556 and FOR-706). The existence of these specialisations supports the stand-alone structure and identity of forensic science, where in such a structure forensic science resembles other stand-alone fields of study in academia (engineering, medicine, etc).

In addition to the statistical analysis conducted on the distribution of forensic science courses across administering departments (Table-4i), analysis was also conducted on the distribution of these courses across various academic levels of offer (Groups I, II, III, IV, and V) in Table-4j. This analysis showed that the majority of the selected programs during the second stage of the selection criteria (78 programs) led to undergraduate degrees in forensic science. Analysis also showed remarkable percentages of non-award degrees (18%) and complete programs (14.5%) which offered both undergraduate and postgraduate education in forensic science.

Distribution of Forensic science Courses across Academic Levels of Offer	
Group I: Non- Award Degrees	**18.00%**
Group II: Minor Degrees	**16.50%**
Group III: Undergraduate Degrees	**32.00%**
Group IV: Postgraduate Degrees	**19%**
Group V: Complete Programs (Undergraduate and Postgraduate Degrees).	**14.50%**

Table-4j

Linking the data that generated these two statistical analyses (Table-4i and Table-4j), the following implications were identified:

- The majority of Group I courses distributed in a 1:2:1 ratio among stand-alone departments for forensic science, administration of justice departments and public safety departments respectively.

- The majority of Group II courses distributed in a 1:4:1 ratio among criminal justice departments, chemistry departments and biological sciences departments respectively.

- Group III courses distributed over various departments with the department of chemistry occupying the highest percentage (20%) as an administering department and the stand-alone departments of forensic science administering 16% of those courses.

- Group IV courses distributed over various departments with the highest percentage (27%) going to the stand-alone departments of forensic science.

- The majority of Group V courses distribute in 1:1 ratio between chemistry departments and stand-alone departments of forensic science.

These results emphasised the attempts of forensic science to emerge as a stand-alone field of study which can be offered at various levels. Overall, statistical analysis showed that 57% of the considered forensic science courses were housed within science departments.

4. The majority of the final selected courses (60%) offered various specialisations within their forensic science programs at both undergraduate and postgraduate levels. For instance, one of the Group III programs (FOR-709) offered 4 various specialisations within its program: BSc (Hon) forensic science, BSc (Hon) forensic chemistry, BSc (Hon) forensic science with physics emphasis, and BSc (Hon) forensic

biology. One of the Group V programs (FOR-706) offered 4 various undergraduate specialisations: BSc in forensic biology, BSc in forensic chemistry, BSc in forensic anthropology and BSc fire investigation and 2 various postgraduate specialisations: MSc in DNA profiling and MSc in document examination. The existence of various specialisations within the one forensic science program promotes a resemblance between forensic science and other applied fields of sciences such as medicine and engineering. Engineering, for instance, possesses a variety of specialisations such as civil, architectural, mechanical, chemical, and electronic engineering. While medicine and engineering are stand alone applied science fields within academia, forensic science has not yet enjoyed a stand-alone academic stature.

5. One of the Group V programs (FOR-706) offered a Master of Science in document examination, where students focused on studying the principles underpinning the scientific analysis of handwriting and signatures, examining printing equipment, typewriters and photocopiers, and identifying forged or counterfeit documents. This program emphasised that this Master's degree is the first of its kind to be offered within academia. This claim might support the scepticism about whether or not uniquely forensic forms of inquiry such as document examination are sciences which can be offered as fields of study or research within academia (Giannelli, 2003, 2006; Henderson, 2004; Risinger and Saks, 2003).

6. Courses within the final selected programs revealed the following relationships to external authorities:

- 73% of the courses emphasised a relationship with police/law enforcement agencies, with some courses (47%) clearly mentioning a direct and strong liaison with police departments (state police, federal police, police academy, etc).

- 73% of the selected courses revealed a link with professional forensic science associations such as AAFS[45] in the United States, NIFS[46]& ANZFSS[47] in

[45] American Academy of Forensic Sciences

Australia, and the Forensic Science Society in the U.K. However, only 2 courses (FOR-757 & FOR-556) out of 15 selected courses revealed that they are accredited by a professional forensic science association.

- One third of the courses revealed links with forensic science agencies.

- 27% of the courses were recognised/ accredited by the national chemical association in their countries. These courses incorporated a heavy chemistry component within their curriculum in addition to the forensic science component.

- More than half of the courses (60%) possessed links with more than one external authority. For example, one course (FOR-766) revealed links with the state police, federal police, state forensic science agency, and the national chemical association in its country.

7. In regard to emphasised career opportunities, Group I courses clearly mentioned that they are mainly directed to personnel already employed within police forces, forensic science centres, and law enforcement agencies in order to provide these personnel with further development and training. As for Group II, III, IV, and V courses, these courses emphasised the following career opportunities:

- Forensic practitioners such as crime scene officers, laboratory technicians, fingerprint experts, forensic chemists, and forensic biologists (emphasised by 83% of the courses).
- Police members (local and federal police) (emphasised by 58% of the courses).
- Professional scientists in chemical, pharmaceutical, food, and molecular biology industries (emphasised by 50% of the courses).
- Public servants in positions such as army (navy), customs, immigration, and national centre for missing and exploited children (emphasised by 42% of the courses).

[46] National Institute of Forensic Science

[47] Australian and New Zealand Forensic Science Society

- Environmental scientists (emphasised by 25% of the courses)
- Insurance consultants (emphasised by 17% of the courses).

In addition to these results, document analysis revealed the following points in regard to employment opportunities within forensic science:

- In the U.S.A, employment in the forensic science domain has steadily grown. For example, one of the courses (FOR-558) reported that up to 10,000 jobs will be available in forensic science in the U.S.A. in the next 10 years. However, job opportunities within forensic science are generally limited and competitive. This fact has pushed some education providers (e.g. FOR-754 & FOR-766) to offer "fall-back" positions within their forensic science programs for students who would like to pursue different careers (e.g. chemist or molecular biologist). To offer such a fall-back opportunity, these programs have included a heavy science discipline (e.g. chemistry and biology) which is offered in addition to the forensic science component.

- Few courses emphasised private forensic science services as an employment opportunity in addition to employment in the public forensic science sector. In the U.K., for instance, forensic science laboratories were traditionally government owned and mainly served the police and the prosecution. Currently, a semi-independent government agency is the largest forensic science provider in the U.K (FOR- 754). In Scotland forensic science services are still maintained by local police forces. However, a number of the private laboratories are competing with police's laboratories (FOR- 706).

8. Police dominance or strong correlation to forensic science was strongly suggested by:

    - The high employment of police members in forensic science field-positions in a number of countries where university qualifications are not prerequisites for applicants to such positions (e.g. FOR-754 and FOR-762),

- The percentage of forensic science courses (73%) which emphasised a relationship with police/law enforcement agencies,
- The percentage of forensic science courses (58%) which emphasised police positions- local and federal- as potential career opportunities,
- The requirement set by some federal police agencies that applicants to vacant forensic laboratory positions within these agencies be members of the police or military forces (e.g. FOR-551, FOR-554, and FOR-556),
- The limited private sector attempts to invest in forensic science as many worldwide forensic science centres and services are still maintained solely by police forces (e.g. FOR-754 and FOR-556),
- The emphasis by non-award forensic science courses (Group I courses) that they are mainly directed towards the training and education of already existing police members and forensic practitioners (FOR-276 and FOR-375). This supports the belief that the police possess strong influence not only on forensic science practice, but also on forensic science education.

9. Programs offering forensic science courses presented different reactions to the strong focus by media and TV shows on forensic science:

➢ Positive messages towards CSI and similar shows which demonstrate the popularity of forensic science (e.g. FOR-558).

➢ Overselling messages which referred to TV shows excessively emphasising the role of forensic science in society's pursuit of truth in civil and criminal matters (e.g. FOR-358).

➢ A warning message (e.g. FOR- 551 and FOR-706) which advised applicants and prospective students that forensic science in reality isn't much like what is revealed on T.V. shows. For example, one of the courses (FOR-551) clearly warned students that jobs like those depicted in C.S.I. don't exist and advised them to hold realistic expectations before entering the field.

4.5.3.1- Summary of Identity Conceptual Attributes

In summary, forensic science possesses a high public profile although it is considered to be a young science and profession. Statistical analysis, in relation to the distribution of the courses among administering departments, revealed limited dominance (23%) of chemistry departments over forensic science courses. This dominance has been exaggerated through literature where there has been emphasis on major or absolute dominance. Such contradiction can be interpreted by the migration of forensic science courses towards biological science departments (10%) and stand-alone forensic science departments/centres (17%) at the expense of chemistry departments. The strong liaison between forensic science, law, and criminal investigation is reflected by the percentage of the courses (13%) administered by departments of criminal justice.

Forensic science education is offered at various levels of academic hierarchy (vocational and higher education). Various specialisations exist within forensic science programs.

The selected programs revealed links with various external authorities, the strongest of which is the linkage with police departments. These programs also reported a variety of career opportunities, the majority of which fell within the public sectors.

Media focus on forensic science was used by a number of the selected programs to oversell their courses. On the other hand, a number of programs warned of T.V. shows which created unrealistic and fictional expectations about forensic science.

4.6- Themes Generated by Document Analysis

Document analysis asserted that forensic science is an implicitly defined field at three epistemological levels: knowledge, practice, and identity. Cross-comparison and synthesis across the identified attributes generated the following themes relating to forensic science education:

1. Forensic science is a high profile field which is dramatically expanding and developing. Such prominence attracts investments from education providers. Forensic science education has expanded over the last two decades for a number of reasons. First, the evolution of new technologies in various fields of interest to forensic science (FOR-551) created a large landscape for media concentration on forensic science topics. This has increased public awareness of and interest in forensic science (FOR-551, FOR-558, and FOR-706). Second, there has been a need to offer academic courses to current members of police and forensic science practitioners (FOR-276, FOR-375, and FOR-358). These members either:

- are newly employed within the forensic science services and in need of formal academic education (often they only hold secondary school education),
- or have been employed well before the emergence of all the advances in science and technology (e.g. DNA profiling, automated fingerprint identification systems, etc). Hence, they are in need of supplementing their experiences with some sort of formal education which emphasises such advances.

Third, the continuous security challenges and the increased use of forensic science by governments and law enforcement agencies (FOR-558) have resulted in creating more job opportunities and expanding the forensic science industry.

2. Forensic science is a very segmented field across various disciplines, scientific applications, and vocational applications. Such segmentation is reflected by the curricular structures organisation forensic science courses within academia. The curricular approaches which were mainly adopted to organise forensic science education were the multidisciplinary and interdisciplinary approaches. The multidisciplinary approach incorporated the various disciplines of interest to forensic science (e.g. chemistry, biology, law, uniquely forensic forms of inquiry, etc). However, it mainly concentrated on the techniques of the one discipline- often chemistry or biology- to engage with forensic science (e.g. FOR-551 and FOR-766).

The interdisciplinary approach integrated the various disciplines to examine the one topic: forensic science. Boundaries between various subjects were maintained and distinct in the multidisciplinary curriculum whilst such boundaries were blurred in the interdisciplinary curriculum (e.g. FOR-276 and FOR-558).

3. Forensic science education suffers uncertainty in regard to:

a. The level of academic offer: Forensic science education exists through various levels of academic hierarchy and in various formats: non-award vocational programs (e.g. FOR-276 and FOR- 375), minor undergraduate courses (e.g. FOR-560 and FOR-551), major undergraduate courses (e.g. FOR-715 and FOR-558), postgraduate courses (e.g. FOR-762 and FOR-554), and the ‘whole educational package’ which incorporates both undergraduate and postgraduate courses (e.g. FOR-706 and FOR-757).

b. The identity of administering departments: The identity of forensic science education segments over the various administering departments. Document analysis showed that chemistry departments remain the most dominant administering department (23%) for forensic science courses/programs. However, this dominance has been exaggerated throughout the literature where there has been emphasis on major or absolute dominance. Following chemistry departments, stand-alone forensic science departments administer a recognisable portion (17%) of the forensic science courses, revealing a tendency within forensic science education to develop as a stand-alone academic structure. Criminal justice departments (13%) remain one of the traditional Administering departments of forensic science due to the strong liaison between forensic science, law, and criminal justice. The emergence of biological science as one of the recognisable administering departments of forensic science education (10%) can be explained by the migration of some forensic science courses from traditional administering departments (chemistry and criminal justice) towards biological science departments. This migration has mainly occurred as a consequence of the emergence of new technologies within biology and biomedical sciences, most importantly DNA technologies. The migration of forensic science courses towards biological science departments and stand-alone forensic science departments has come at the expense of chemistry departments.

4. Forensic science knowledge comprises a science component and a specific forensic technical component. Whilst the science component can be delivered within an academic university setting, the technical component requires a practice-based setting. This is informed by the percentage of forensic programs (54%) in the document analysis which offered an internship through their curriculum, in addition to the high percentage of programs (94%) which emphasised practitioners' contribution in course delivery.

5. There is differentiation between field practice and laboratory practice in terms of education, jobs prerequisite, and identity of practitioners. In terms of education, non-award forensic science courses (e.g. For-276 and For-375) which are non-scientific degrees and award forensic science courses which are not specialised science courses (e.g. For-715 and For-558) were more directed towards forensic field career opportunities. On the other hand, specialised forensic science courses which emphasised specialised heavy science components (chemistry or biology) within their curriculum (e.g. For-766, For-754, For-556, and For-757) were more directed towards forensic laboratory career opportunities. In terms of jobs prerequisites, document analysis reported that there was no consensus on the obligation of a tertiary science degree to practice forensic science, particularly in regards to forensic field positions. However, document analysis reported consensus on the prerequisite of a science degree to operate in a forensic laboratory (e.g. FOR-754, FOR-551, FOR-757, and FOR-766). In terms of identity, the selected forensic science programs revealed that laboratory practice is often more undertaken by civilians than field practice, where police still hold the roles of crime scene investigators in many jurisdictions (e.g. FOR-551 and FOR-754).

6. The nature of practice in forensic science is affected by the individual legislation and regulatory schemes characteristic of each individual jurisdiction. Such legislation and schemes regulate both the way forensic science is practiced and the individuals practising forensic science.

7. Typically, forensic science practice had been an explicit public practice mainly housed under the police umbrella. However, over the last two decades, there have been various approaches by the private sector to invest in the forensic science industry and within the various forensic specialisations such as paternity testing, handwriting examination, etc (e.g. FOR-551 and FOR-757). These approaches remain limited with respect to governments' investment in the forensic field (FOR-706). This makes job opportunities within forensic science restricted to vacancies within the public sector. This fact has pushed many education providers to emphasise a heavy science component within their forensic science programs which create opportunities for their graduates to seek "fall-back" positions (e.g. FOR-754 & FOR-766). These fall-back positions are often career opportunities as professional chemists or biologists depending on the discipline emphasised within the course (chemistry or biology).

8. Document analysis reported that practitioners' contributions in course delivery mainly existed in one of three formats: major, specific-subject, and minor contributions. The extent to which practitioners may contribute in course delivery seems to be strongly dependent and directly proportional to the extent of **socialisation** between the university itself and the relevant law enforcement authorities. For example, in a number of courses (e.g. FOR-556 and FOR-558) the extent of socialisation allowed students to be exposed to real practice-based settings. Despite the differences in the format and the extent of socialisation from one course to another, practitioners' contributions in course delivery invites Bernstein's notion of 'social groups' (2000). Through such contributions, forensic science practitioners appear to be a social group reflecting its preferences of how to shape, structure, and deliver forensic science knowledge within academia.

4.7- Grey Areas Awaiting Clarification

Document analysis expanded and extended the minor findings of the typology, initially conducted in chapter 1, into major findings about forensic science education. Document analysis provided an anatomy of forensic science education from three perspectives:

- The knowledge base organised and transmitted through forensic science courses/programs
- The place, form, and extent of forensic practice in course organisation and delivery,
- The identity of the field as possessed by course type, course location, relation to other courses, evidence of course outcomes, and relationship to external authorities.

Despite the major and critical implications generated by the document analysis about forensic science education, these findings are more likely to be hypothetical rather than practical. This is because published curricula of forensic science courses/programs considered in the document analysis may be seen as revealing ‘static’ data about the knowledge, practice, and identity attributes within forensic science education. Data might be seen as static because it was generated from information published on the internet. Data might be seen as reflecting what curriculum coordinators wish to see, have, and cultivate rather than what the actual implementation of the curriculum reveals, displays, and generates. Hence, there is a need to explore forensic science education from a more dynamic real-life perspective which emphasises everyday lectures and lessons, daily practices, and regular interactions at forensic science centres, crime scenes, courts, and police departments. Hence, it is imperative for the research methodology to adopt – in addition to document analysis- a more dynamic methodological approach which would generate data within a real-life context. Such data can be generated by interviewing:

1. forensic science educators about their perceptions of forensic science education based on their everyday interactions with the curriculum and students,
2. forensic science practitioners about their everyday practice and the knowledge they apply to perform such a practice, and
3. members of associated professions to forensic science (e.g. police and legal practitioners) about their everyday exposure to forensic science at crime scenes, police departments, and courts.

Therefore, the second stage of the research methodology will comprise semi-structured interviews with forensic science educators, practitioners, and members of associated professions. This stage will be fully addressed and detailed in chapters 5, 6, and 7.

The conceptual attributes and implications generated by the document analysis will guide the second phase of the research methodology and will be cross-compared and examined with the themes and implications generated by such phase for final analyses and insights.

Document analysis has identified 'grey areas' which need clarifications by semi-structured interviews. These ill-defined issues involve the nature of forensic science knowledge, practice, and identity and how such a nature relates to forensic science education. Issues which require more clarifications are:

a) issues related to the nature of forensic science knowledge base:
   - The essential knowledge base needed to practice as forensic scientist
   - The curricular approach needed to organise such a knowledge base
   - The pedagogy needed to deliver such a knowledge base

b) issues related to the nature of forensic science practice:
   - The factors shaping and affecting forensic science practice
   - The nature of practice between field work and laboratory work
   - The competencies essential for the conduct of such practice

c) issues related to the nature of forensic science identity:

- The extent to which forensic science is a distinct applied knowledge field or merely a technical derivative of existing fields.
- The nature and extent of the relation of forensic science to police forces, law enforcement agencies, and judicial system.

Clarifications on the nature of forensic science knowledge, practice, and identity by semi-structured interviews (Chapters 5, 6, and 7) would lead to identifying whether or not forensic science should have an explicit presence in higher education, and if so, how forensic science education should be, structured, organised, and delivered to relate to and reflect upon the nature of forensic science.

Chapter 5: Conceptions of Forensic Science Knowledge

5.1- Introduction

The previous chapter (Chapter 4) constituted the first phase of the research methodology. Chapter 4 presented a detailed document analysis conducted on 15 forensic science courses/programs, selected from 190 forensic science courses/programs from countries worldwide. This analysis yielded critical and significant implications about the current status of forensic science education and how such an education reflects forensic science knowledge, practice and identity. Nevertheless, document analysis as an overall qualitative approach may not reveal as much as an interactive methodology which involves face to face interviews of actual personnel about their perceptions, informed opinions, and expectations (Sproul, 1995). Therefore, the research adopted semi-structured interviews to constitute the second phase of the research methodology. This strategy has resulted in the generation of conceptual categories and themes about forensic science knowledge, practice and identity. Semi-structured interviews- with the aid of document analysis- will generate insights and implications in relation to the major research question and associated minor questions.

This chapter is the first of three chapters which constitute the second phase of the research methodology: semi-structured interviews. Chapter five presents and analyses interviewees' (educators, practitioners, and members of associated professions) perceptions and conceptions of forensic science knowledge. Interviewees' perceptions and conceptions of forensic science practice and identity are respectively addressed in chapters six and seven.

Chapter five addresses five qualitative conceptual categories which were identified by the research as being major descriptive conceptions of forensic science knowledge. The connotations of each category are addressed in this chapter with representative quotations from the interview data to convey the nuances of meaning as is customary in data coding and analysis in qualitative research (Creswell, 1998; Sproull, 1995).

Data analysis in this chapter is organised in three sections (section-5.2, section-5.3, and section-5.4). Section-5.2 presents topic coding, where five conceptual categories of description relating to forensic science knowledge were identified. These conceptual categories were revealed by the perceptions of the research participants. The stance of each of the three groups of participants (forensic science educators, forensic science practitioners, and members of associated professions) from each of the identified categories of description is individually presented.

Section-5.3 presents an inter-categorical analysis of each of the five categories of description. In this section, the overall stance from each category of description is presented. Such overall stance was identified consequent to conducting a conversation (Pinar, 2004) between the perceptions of each group of participants in regard to each category of description. Hence, inter-categorical conceptual attributes relating to forensic science knowledge were identified.

Section-5.4 presents a cross-categorical synthesis of the identified inter-categorical conceptual attributes (section-5.3). Pedagogical discourse (Bernstein, 2000) was conducted between the identified inter-categorical conceptual attributes, where these attributes were re-contextualised and re-conceptualised into forensic knowledge themes. This section identified four themes relating to forensic science knowledge. These themes were then explained through the preparation of four practical exemplars. Finally, implications for forensic science education from a knowledge perspective were generated. An organisational chart representing the various stages of data analysis process in this chapter is presented in Figure-5a.

Epistemologically and ontologically, knowledge, practice, and identity overlap, where any one conception often possesses implications for the other two conceptions. For instance, an identified conception about forensic science knowledge would reflect the nature of forensic science practice, which in turn reflect the 'reality' or 'being' of forensic science as a field of knowledge and practice. Hence, segregation between these concepts remains artificial rather than natural. However, such segregation is essential for simplifying data analysis.

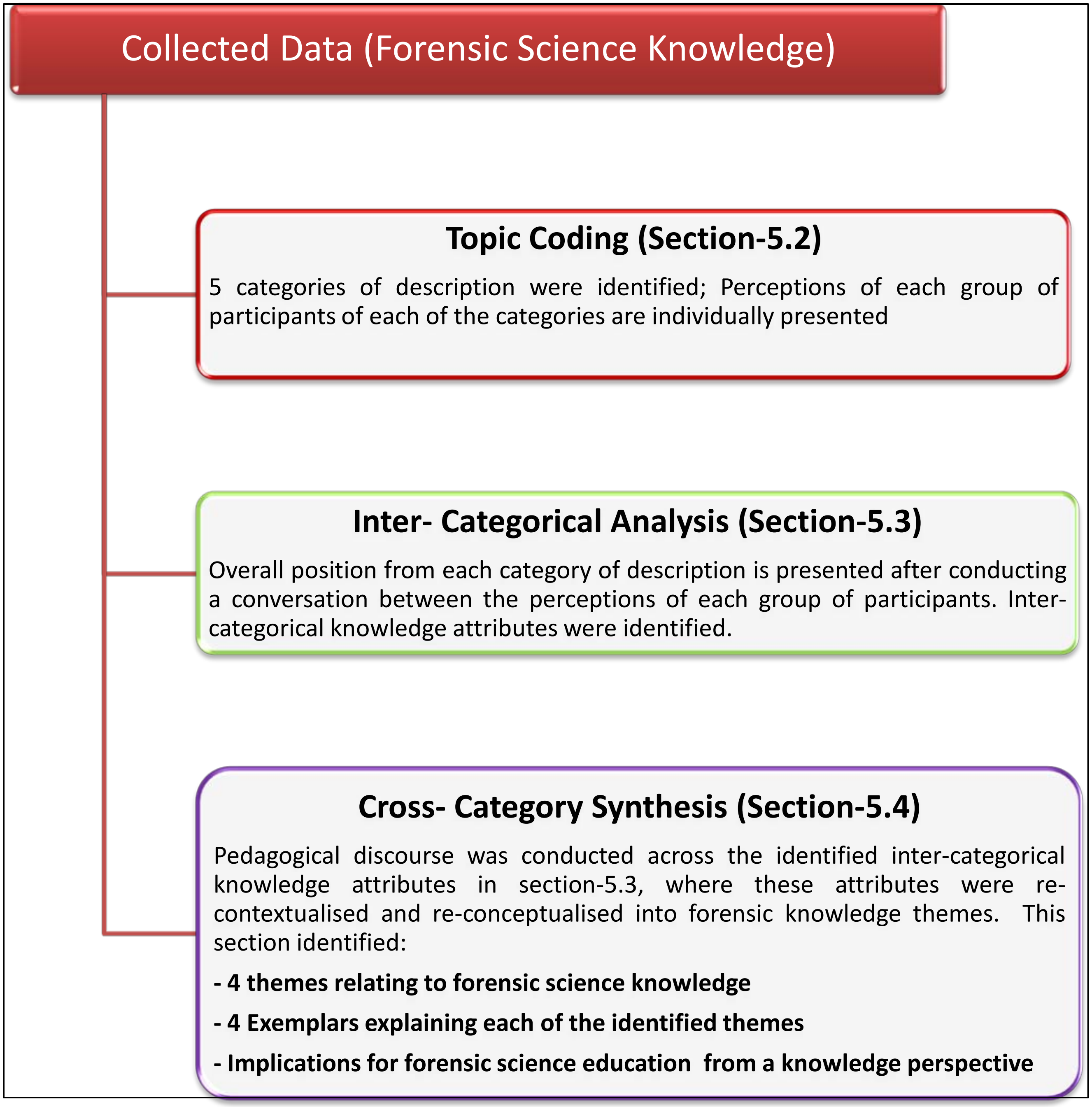


Figure-5a

5.2- Topic Coding: Categories of Conceptual Knowledge Attributes

In this section, the research undertook topic coding to identify categories of descriptions which best reflect forensic science knowledge as represented by the responses and perceptions of the participating interviewees. Richards and Morse argue that topic coding 'entails creating categories or recognizing one from earlier, reflecting on where it belongs among your growing ideas, and reflecting on the data you are referring to and on how they fit with the other data coded there' (2007:139). The research identified five categories of description which represent major conceptions of forensic science knowledge. For each identified category of description, the responses and perceptions of each group of participants relating to such category were addressed individually. Inter-categorical analysis across the stances of the three groups of participants from each of the five categories is presented in the following section. The five identified categories of descriptions relating to forensic science knowledge are:

- **Category 1:** Education backgrounds and experiences of participants
- **Category 2:** Emphasised forensic science knowledge base and competencies
- **Category 3:** Curricular approaches through which forensic science knowledge is to be organised
- **Category 4:** Pedagogies needed to emphasise forensic science knowledge.
- **Category 5:** Differentiation between the knowledge base and competencies of forensic science experts with tertiary education and those without.

5.2.1- Category 1: Education backgrounds and experiences of participants

In this category, the research identified the various education backgrounds and knowledge base of: a) educators (first group participants) who are responsible for knowledge transmission, training, and research in forensic science; b) practitioners (second group participants) who apply forensic science knowledge at the crime scene and in the laboratory and present their findings at court; and c) members of associated professions (third group participants) who possess a *bona fide* relation with forensic science and interact with forensic practitioners on a regular basis.

5.2.1.1- Education Backgrounds and Experiences of the First Group Participants (Forensic Science Educators)

Most participating educators (3 of 4 participants) hold postgraduate qualifications in a scientific discipline: EP1 holds a BSc and MSc in biology; EP2 holds a BSc, MSc, and PhD in chemistry; and EP4 holds a BSc and MSc in agricultural studies and both a PhD and a post doctoral degree in biology- specifically in genetics. All of those educators have acquired forensic science knowledge subsequent to their employment in various forensic science laboratories. After practicing forensic science (laboratory) for a number of years, they have moved to forensic science education and training, where they are actively involved in forensic science teaching, training, research and development.

Interviewee EP3 is the only participant who holds a BSc and PhD majoring in forensic science (speciality in forensic chemistry), where both degrees are specialised forensic science degrees incorporating a heavy chemistry component. EP3 described himself as “unique” because he is “one of two professors in the whole Australian Territory who holds a PhD in forensic science” (EP3, p.1). The participant attributed this mainly to the worldwide scarcity of universities which offer a PhD in “forensic science”, for it is more common to have universities offering PhDs in one of the major science streams (e.g. biology and chemistry), where the research topic is focused on forensic science or related to an area of interest to forensic science. EP3 is currently involved in lecturing in forensic science and forensic chemistry subjects, supervising forensic science research, and administering an academic forensic science department.

All participating educators actively contribute to advisory committees on forensic science education and forensic science conferences at both the national and international levels.

5.2.1.2- Education Backgrounds and Experiences of the Second Group Participants (Forensic Science Practitioners)

The second group of participants comprised forensic science practitioners of various specialisations and levels of expertise. Second group participants differentiate into two subgroups:

- Field practitioners (crime scene investigators and experts of unique forensic forms of inquiry): PP1, PP2, and PP4.
- Laboratory practitioners: PP3, PP5, and PP6.

The second group participants' positions, duties, and academic backgrounds are listed as follows:

- The first participant (PP1) is a firearm and ballistics officer. His duties are mainly examining firearms and tool marks. He joined the police at the age of 16. He then applied to the firearm section of the forensic services. Prior to joining the firearm section, PP1 did not have any prior forensic knowledge. The participant has been practicing in the firearm section for 26 years.

- The second participant (PP2) is a sergeant in the police who is practicing as a senior crime scene examiner. PP2 holds a bachelor degree in chemistry. He joined the police force 18 years ago after practicing as a chemist for a short period of time. The participant holds a diploma in photography and has been practicing as a crime scene examiner for 13 years.

- The third participant (PP3) is a forensic biologist. His duties are mainly examining and analysing biological evidence at the forensic biology laboratory. He also prepares court reports and statements and appears as an expert witness at court when required. PP3 had finished a bachelor degree in biological sciences with honours research on genetics prior to joining the forensic science centre. His honours research was conducted in collaboration with the forensic science centre where he is currently employed.

- The fourth participant (PP4) is a forensic expert at the Vehicle Examination Unit. His role mainly incorporates the examination of suspected and stolen vehicles. Prior to his career at the forensic science centre, PP4 practiced as a qualified motor mechanic after he had completed a 4 years apprenticeship at TAFE. PP4 has been in the forensic field for 13 years.

- The fifth participant (PP5) is an assistant technician at a forensic chemistry laboratory. PP5 completed a certificate IV in forensic science at TAFE prior to joining the forensic area. She joined the forensic science centre at an entry level 1. Subsequent to joining the forensic science centre, she commenced studying chemistry at a tertiary level. Her duties include assisting in laboratory work and in crime scene investigation, especially photography and arson cases.

- The sixth participant (PP6) is a senior forensic biologist and a case reporting officer. Prior to joining the forensic field, PP6 had completed a bachelor degree in biological sciences and an honours degree in genetics. His honours research was conducted in collaboration with the forensic science centre where he is currently employed.

5.2.1.3- Education Backgrounds and Experiences of the Third Group Participants (Members of Associated Professions)

The four members of associated professions were selected from amongst those fields (judiciary, police, and forensic psychology) which are the most correlated/associated with the forensic science field. The list of third group participants is as follows:

- The first participant (AP1) is an accredited forensic psychologist. She holds a bachelor degree in behavioural sciences, a graduate diploma of adolescent child psychology, and a Master’s degree in forensic psychology.

- The second participant (AP2) is a senior police officer. He finished secondary education and then joined the police force in 1982. He started his career as a criminal investigator, where he was required to make use of forensic science services. Since then, he has gradually been promoted in positions. AP2 currently holds a very senior position within the police forces. He is an advisor with respect to all crime related issues in one of the Australian metropolitan regions covering more than 140,000 residents.

- The third participant (AP3) is an accredited barrister. He holds an honours degree and a Master's degree in law. AP3 has practiced in personal injury, criminal law, coroner's enquiries, and a range of other areas of the law. As for the forensic science competencies, AP3 has acquired a general forensic understanding throughout regular interactions with forensic experts.

- The fourth participant (AP4) is an accredited barrister. AP4 started his career as a police officer in London, during which time he commenced his studies in law. He left the police force and became a qualified barrister in England. He moved to Australia around 3 decades ago. Since then, he has been practicing in the field of criminal law and acting as a defence lawyer in some criminal cases and as a prosecutor in others.

5.2.1.4- Summary of the First Category of Description

The participants in the semi-structured interviews were distributed amongst three groups: educators, practitioners, and members of associated professions. The majority of the participating educators hold a postgraduate degree in one of the main science streams (chemistry or biology). These educators acquired their forensic science knowledge subsequent to practicing forensics for a number of years before starting their careers as educators in the field. Only one of those educators holds a bachelor and a PhD degree majoring in forensic science.

The participating practitioners differentiated into two categories. The first comprised field practitioners who are sworn police officers. The second comprised laboratory practitioners who are unsworn police members (civilians). The majority of the participating field practitioners did not hold a tertiary qualification. All of the participating laboratory practitioners either completed a tertiary qualification in one of the main science streams (chemistry or biology) or were enrolled in one.

Third group participants represented professions which are associated with forensic science. This group of participants comprised: a forensic psychologist, a senior police advisor, and two barristers.

5.2.2- Category 2: Emphasised Forensic Science Knowledge Base and Competencies.

In this category, the research identified the knowledge base, competencies, and skills essential for forensic science practice as emphasised by participants through their experiences, perceptions, and expectations.

5.2.2.1- Essential Forensic Knowledge Base and Competencies as Emphasised by the First Group Participants.

Educators who participated in this research distinguished between forensic science education delivered to higher education students and training delivered to novice practitioners. Participants often referred to the education offered to higher education students as "forensic science education", whilst they referred to that offered to newly employed practitioners as "forensic science training".

Forensic Science Education

With respect to forensic science education, the participating educators agreed that any forensic science education should emphasise a strong science component, because for an individual to become a proficient forensic scientist, s/he must be a proficient scientist first and foremost.

To be a forensic scientist or practitioner- regardless of which forensic area-one needs to be a scientist, a good scientist, first and then acquire the forensic skills on top of the science degree. It is very essential to first acquire the science underpinning any forensic technique before acquiring such technique … a science component must be strongly emphasised and covered through proper undergraduate education before joining a forensic science position (EP1, p. 3).

The science part in forensic science education cannot be compromised. We want graduates of forensic science courses, for example forensic chemistry, to be as good as a normal chemist (EP3, p. 4).

Participant EP2 argued further that forensic field practitioners need to possess a good science background, because they do apply - even if unknowingly- science in every task they perform:

People who don't realise that things like firearms, they not only learn about lams and grooves and which can fire what… but also they use science to determine range, how far away? They use chemistry to do the analysis of the gun-shot residue... so if you want the rounded person, you need the degree first, a science degree such as chemistry (EP2, p. 4).

Moreover, EP4 argued that a forensic science course should incorporate not only a heavy science component, but also a specialised one. For example, according to EP4, a forensic biology course should incorporate a heavy genetics component with a focus on forensics.

In terms of biology the specialty thing is genetics, but again genetics is very wide... And things about cloning and the like is not relevant to the forensic side of things, while DNA analysis, PCR, inheritance, population genetics, mutation are [relevant], so a forensic biology course needs to prompt those specific areas of interest to forensic science where disciplines should be funnelled through that prism [relevant forensic topics] rather than teaching students about stem cells, cancer, etc. I mean there is always elements that are relevant but if you want to train somebody from the forensic perspective, you train them in those elements in genetics that are relevant to the field, and I think a lot of the courses aren't like that, they incorporate both relevant and irrelevant data (EP4, p. 6).

As for the introduction of forensic science in tertiary education, participants argued that such introduction should never be at the expense of the pure science components. There was consensus amongst all first group participants that the science component in any course must not be compromised for the sake of the forensic science component. This agreement is based on the participants' belief that the forensic science component can be compromised in a higher education course, because it can be recovered/ acquired later on through on-the-job training. However, the science component cannot be compromised because -from a practical viewpoint- it can neither be recovered nor taught later on through workplace learning. This is evident from the following excerpts:

> *The science component can neither be compromised nor recovered through on job training…* (EP1, p.3).
>
> *The science part cannot be compromised, otherwise you generate graduates that are unemployable, as most industry players would always go for a graduate with a strong science degree rather than a graduate with a weak science degree but strong forensic science component, because they can always fill gaps in the forensic science education but they can't fill gaps in the science education* (EP3, p. 4).

The third participant (EP3), who administers an academic forensic science department, stressed that a forensic science course, for instance forensic chemistry, should graduate students who are as good chemists as those from pure chemistry courses. The forensic science component could be 'more or less' depending on the universities' resources and facilities:

> *The forensic chemistry course [which is offered by participant's department] constitutes of a very heavy chemistry component with a small forensic science component... We want graduates of forensic science courses, for example, forensic chemistry, to be as good as a normal chemist but to get on top of chemistry forensic education right from the start. Therefore, if one compares our program, if one wants to do chemistry … one would do three years but there would be a lot of electives in it. If you look at the degree we're having in forensics, it's four years with honours at the end so there is a research component and there is no electives, as the elective subjects have been replaced*

with compulsory forensic science subjects. The forensic science component may be more or less depending on university's circumstances, facilities, and links (EP3, p. 4).

In addition to the strong science component, a number of participants argued that it is beneficial for a forensic science course to emphasise a sound legal knowledge.

> *Forensic science practitioners should not only be competent in their discipline… but they also should have a good knowledge base of the legal system, court hierarchy, and legislation* (EP1, p. 3).
>
> *Another area that is very useful to incorporate is the whole law side of things... that would be helpful for a person to have a general understanding of the law…* (EP4, p. 6).

<u>Forensic Science Training</u>

The knowledge base, which needs to be organised and emphasised through training sessions, seminars, workshops, and/or short courses subsequent to employment in a forensic science centre or agency, is more of a technical/vocational nature. In this respect, participant EP4 emphasised his experience in training regional crime scene officers in matters relating to forensic biology:

> *The main topic that was emphasised with the regional crime scene officers was about how best to collect samples at the crime scene. These people are not scientifically trained, they'd got to do lot of tasks but one task is the collection of samples, and we need to advise them on how best to do this: what area to target, what samples are more important than other types of samples... When we get down, lots of samples are straightforward but there are certain types that are difficult and we focus on how best to collect those, we explain to them both the background information and practical ways on how best to approach such samples. And we also again talk about how it relates to the bigger picture because they do their role of collecting the samples but at the other hand, they do not know what goes on with it* (EP4, p. 5).

When EP4 was asked about the biology knowledge emphasised in the training sessions, he answered:

Very little; we don't give in-depth knowledge about the DNA structure and profile because that's beyond the scope of a lot of practitioners, partly because of their educational background... but because they do not have understanding of the process and its consequence, they might not have appreciation of how important it is to collect the sample in a certain way so we try to fill those gaps internally as much we can in the limited time we have (EP4, p. 5).

Generic Skills

As for the competencies and skills which are essential to be emphasised within forensic science education and training, participating educators asserted a number of these competencies and skills, the most important of which are communication skills and critical thinking. Communications skills enjoyed consensus amongst the first group participants, where all the participants noted the importance that any forensic practitioner- despite his/her speciality area- be able to efficiently and clearly communicate his/her results both in writing and orally.

Despite the primary necessity for a forensic scientist to be a good scientist, there is no point in being a good scientist if you are unable to properly communicate your results to a vast range of audiences including judges, juries, prosecution, and defence (EP2, p. 6).

Students need to acquire communication skills, both written skills and oral skills, because once they join the field, they need to be able to respond quickly and precisely and be able to communicate their results to a variety of audiences (EP3, p. 7).

Critical thinking also enjoyed consensus amongst the first group participants on being one of the key competencies for success in any forensic science role. This is evident from the following excerpts:

Graduates need to possess critical thinking (EP1, p. 6).

I expect graduates to be heavily proficient in problem solving and critical thinking because I really think that if they want to work in a forensic laboratory they must be able to think critically, sometimes you need to look outside the box, you have to look at complex issues and problems …(EP3, p. 7).

Summary

The participating educators asserted that any forensic science education should emphasise a heavy specialised science component because forensic practitioners- whether they are laboratory or field practitioners- are first and foremost scientists. They argued that whilst the forensic science component may be compromised in any higher education course as it can be recovered later through on-the-job training, the science component may not be compromised in a course of study as it is very hard to recover at a later stage. These participants also asserted that it is useful for forensic science graduates to possess a sound legal knowledge; however, it is imperative that these graduates possess critical thinking and high communications skills.

5.2.2.2- Essential Forensic Knowledge Base and Competencies as Emphasised by the Second Group Participants.

Opinions and viewpoints expressed by second group participants in relation to the knowledge base and competencies they apply during their everyday activities and tasks can be divided into two main opinions:

- The first opinion considered that most of the activities that forensic practitioners do relies on experiential knowledge.
- The second opinion considered that the knowledge applied through everyday practice is a combination of both theoretical and experiential knowledge.

Experiential Knowledge

Practitioners who supported the first opinion were mainly field practitioners. These practitioners argued that the knowledge and competencies they use are mainly acquired through on-the-job training and workplace learning and nurtured through years of experience:

> *The knowledge we apply in our everyday practice is technical based* (PP1, p. 2).
>
> *The knowledge and competencies you acquire are mainly through experience, through attending hundreds and hundreds of crime scenes* (PP2, p. 3).

> *With our work we do construction and observation of vehicles, matching up to identify its owner, and only experience would enable you to do that* (PP4, p. 5).

These practitioners asserted that through their everyday practice they do not apply ‘rocket science’, just very basic and elementary scientific rules. They perform their tasks mainly through acquired experiential knowledge.

> *We don’t use physics, that’s why people get confused with ballistics, I think well, you will hear “ballistics involves a lot of physics, so your work must be more scientific”, but in 26 years I’ve never had to use physics as means to explain a process in court. Ballistics have never been an issue in court … the main issues in court involve whether or not a particular bullet has been fired from a particular firearm, the condition of the firearm whether it was safe or unsafe...* (PP1, p. 3).

> *When you break down what we actually do, it’s not rocket science, we’re really just recording, collecting, putting in a bag, and passing it on for someone else to look at… the physical aspects aren’t that difficult and they’re certainly acquired through experience… the maths we use is on a basic level like year 9 Pythagoras maths* (PP2, p. 3).

Field practitioners reported that through the conduct of their practice they use their examination and identification skills to examine and identify exhibits, then they rely on their critical thinking in linking or eliminating such exhibits from an investigation:

> *Competencies we use are broad because you’re drawing on previous expertise; you’re looking for certain evidence which can assist the process of identification… For example in that last case I investigated, I was looking at range determination as in most cases when a person is about to shoot another person, introduces space for escape... it would be highly unusual to not to introduce such a space unless it’s a person who’s bound and unable to move… this forms part of the process of elimination... with the fired bullets we need to identify whether or not this bullet has been shot from a suspected firearm…* (PP1, p.3).

Theoretical and Experiential Knowledge in Everyday Practice

Participants who supported the second opinion, that forensic science is a combination of theoretical and practical knowledge, were mainly laboratory practitioners. Those participants asserted that the knowledge they use and apply in their everyday practice is a combination of both theoretical knowledge, which is mainly acquired through prior formal tertiary education, and experiential knowledge, which is mainly acquired through workplace learning and experience. This is evident from the following excerpts:

> *The knowledge we use is a combination of theory and experience* (PP3, p.4).
>
> *I think it's [knowledge used] a combination of theoretical and probably even a bigger component of actually practical experience that gives you the competency* (PP6, p.6).

Laboratory practitioners emphasised that the knowledge base and competencies they apply in their everyday practice mainly relate to:

a) The scientific principles, theories, and fundamentals in their speciality area (e.g. chemistry or biology) when it comes to work within the laboratory:

> *Definitely chemistry principles and fundamentals underpin nearly everything we do in the laboratory …* (PP5, p.5).
>
> *The majority of our work is based on biology… a key aspect in our work is the DNA profile interpretation. We get a lot of DNA results back, sometimes they're complex mixtures and require a lot of thinking and you can spend a lot of time looking at DNA results and comparing them to reference samples.* (PP6, p.6).

b) Experiential knowledge and experience when laboratory practitioners are called to attend crime scenes and assist in fieldwork:

> *I am sometimes called to crime scenes to examine things such as bloodstain pattern analysis … I suppose the biology side of it does not really come into too much at the scene, because you cannot do too much testing other than some very basic tests: that's to determine*

> *whether something might be blood or not... you need to know how best to sample it and how much of the sample to actually collect so that in order to have enough material to work with back here at the lab* (PP3, p. 4).

> *With the fire scenes, we need to take photographs... you've got to be trained in how to attend crime scenes; how to liaise with people; for example, when you arrive you have scene guards, you have to introduce yourself and make sure they've taken a note of what time you're arriving, who you are and who you're with …* (PP5, p. 5).

Laboratory practitioners emphasised statistics as being complementary to their every day practice:

> *Statistics is certainly a skill that you do need in this profession … I wish I've had more background in it because it is very important… you can do all this work [DNA profiling]... but at the end, you need to evaluate the strength of your evidence... you can only do this by statistics... the statistical number must be attached to it, if you can't explain that to the court, then there is no point for it…* (PP3, p. 4).

Additional Required Knowledge and Generic Skills

The majority of practitioners asserted the importance of legal knowledge in their practice.

> *Knowledge about what the legal world actually wants from you also builds up your experience of what you need to pick up from the scenes from what you may be asked.* (PP2, p.3)

> *Anyone really at any given time could potentially be called into court... Acquired knowledge needed involves the overall process: the different types of courts, what to be expected from an expert witness and obviously things like professionalism* (PP6, p.6).

All of the second group participants stressed communication skills as essential competencies for forensic practice:

You also need to be competent in giving oral presentations at court (PP2, p.3).

Also a key task is writing statements; spend a lot of time on a computer, basically putting all the results together into a statement… (PP6, p. 6).

<u>Summary</u>

The opinions of the participating practitioners divided between two opinions: the first considered that the knowledge applied through everyday practice is mainly experiential knowledge, whilst the second stressed that such knowledge is a combination of both theoretical and experiential components. There was consensus amongst all of the second group participants on the importance of communications skills and critical thinking in the conduct of forensic science practice.

5.2.2.3- Essential Forensic Knowledge Base and Competencies as Emphasised by Third Group Participants.

Participating members of associated professions expressed their perceptions about the content which needs to be incorporated in forensic science education. These perceptions have been formed as a result of participants' backgrounds, professions, and observations of the skills and competencies displayed by forensic science practitioners whilst performing their jobs.

Despite the different perceptions about what forensic science education should/should not incorporate, the majority of the participants agreed that forensic scientists need to be "good scientists" and specialists in their area of expertise.

I want forensic scientists to be good scientists, specialists in their fields (AP1,p. 1)

Forensic practitioners need to be proficient scientists because at the end of the day science is what they are delivering to courts as witness experts (AP3, p. 2).

As for the competencies which should be emphasised by a forensic science course, there was consensus amongst all participants on communication skills as being vital for the forensic science field.

> *Being able to communicate their results to a range of associated personnel such as psychiatrists or psychologists …* (AP1, p. 1).

> *A great part of a forensic scientist's work in a prosecution case is really how they present themselves in court* (AP2, p. 3).

> *Communication skills at court of law, the ability to convince, the ability to present properly, the ability to answer questions when cross examined, those range of competencies are critical factors to how much his/her [practitioner] testimony would contribute towards the outcome of the trial* (AP4, p. 3).

In summary, the majority of the third group participants stressed the necessity for forensic practitioners to possess heavy scientific knowledge and proficient communication skills.

5.2.2.4- Summary of the Second Category of Description

There was consensus amongst participating educators that any tertiary forensic science course needs to incorporate a heavy specialised science component, because any forensic practitioner is first and foremost a scientist. They argued the introduction of forensic science in a tertiary course should never be at the expense of the science component. They also stressed the importance of emphasising a sound legal component and competencies such as critical thinking and communication skills within the syllabus of a forensic science course.

The second group participants expressed two main opinions. The first opinion, supported by field practitioners, considered that most of the activities performed by forensic practitioners rely on experiential knowledge. The second opinion, supported by laboratory practitioners, considered that the knowledge applied through everyday forensic practice is a combination of both theoretical and experiential knowledge. However, there was consensus amongst field and laboratory practitioners on the importance of critical thinking, communication skills, and moderate legal knowledge for their practice.

The majority of the third group participants argued that forensic scientists need to be good scientists and specialists in their areas. Forensic practitioners, according to third group participants, must possess good communication skills.

5.2.3- Category 3: Curricular Approaches through which Forensic Science Knowledge is to Be Organised.

In this category, the research identified the curricular approaches through which forensic science knowledge needs to be organised as emphasised by the three groups of participants.

5.2.3.1- Curricular Approach through which Forensic Science Knowledge is to be Organised as Asserted by the First Group Participants.

There was an agreement amongst all participating educators that the best curricular approach, through which forensic science education is to be organised, is the multidisciplinary approach. Participants argued that the nature of forensic science demands that students learn through a number of lenses but ultimately specialise in only one discipline. This discipline needs to be a science discipline (e.g. chemistry or biology). This stance was reflected by the perceptions of each of the participants.

EP1, for instance, asserted that forensic science education is best delivered through a multidisciplinary approach rather than an interdisciplinary approach because ‘if you want to bring all the disciplines together properly, then it will be a thirty-year course or you do everything at a really superficial level and then you mince around the beef’ (EP1, p. 2).

EP2 argued that ‘[students] have to understand the full context which means that they have to understand all of these bits of disciplines; however, they have to be specialists in one discipline’ (p. 3). This discipline according to EP2 should be one of the main streams of science because “lab directors want people with strong science backgrounds... forensic competencies are then acquired through training” (p. 4).

EP3 teaches a number of subjects which follow an interdisciplinary approach because the nature of those subjects demands such an approach. However, EP3 asserted that despite the few interdisciplinary subjects which may be introduced in the curriculum, the overall curricular approach needs to be a multidisciplinary approach, where 'students see the field from various angles but specialise and use one science discipline at the end' (p. 3). EP3 argued against an overall interdisciplinary approach, because such an approach "generates unemployable graduates … who are probably good to make comments and write little stories in the media about forensic science, but who are not proficient enough to work in a forensic laboratory' (EP3, p. 3).

In this respect, EP4 argued that 'applicants to a forensic science position should have a good knowledge base of the area that is relevant: genetics for working within forensic biology, and chemistry for working within forensic chemistry' (p. 6). This is because 'you want people with specialist background in each of those… capable of doing a specialty tasks… you would not want a general forensic person' (EP4, p. 6).

In summary, there was consensus amongst all the participating educators that the nature of forensic science demands a multidisciplinary curricular approach, where students can examine forensic science from various lenses, but ultimately they specialise in only the one discipline.

5.2.3.2- Curricular Approach through which Forensic Science Knowledge is to Be Organised as Argued by the Second Group Participants.

Laboratory practitioners argued that the multidisciplinary approach is the one needed to organise and emphasise forensic knowledge in laboratory practice. They asserted that although forensic practitioners do not operate in isolation and need to be aware of the variety of forensic areas, they need to be specialists in only one area.

> *People might do a forensic science course over 3 or 4 years which covers all areas but then when they actually get into the job, the job is much more*

specialised than what their education was, so all of a sudden a lot of that material that they were studying over that long course is not relevant to the job they're actually doing… we don't work in complete isolation; however, you need to be a specialist in your area (PP6, p. 9).

I guess in this area [forensic biology area] biology is impartial and you should have a strong background in the biological sciences to be able to perform your every day work (PP3, p. 9).

The acquiring of field knowledge and competencies, as argued by all second group participants, occurs best through an interdisciplinary approach. This is because practitioners draw on a number of disciplines to perform the one task such as blood pattern analysis.

The knowledge of blood stain pattern analysis incorporates physics, biology, chemistry and maths …the physics component involves the natural laws of motion... the types of force that may be subjected to matter... viscosity and surface tension… As far as biology goes, we do talk about the intrinsic and extrinsic clotting of blood and the characteristics of blood. As far as chemistry goes... we might be talking about moisture or humidity … so it certainly draws upon a number of disciplines (PP2, p. 9).

Blood pattern analysis is one of our major concerns when we attend crime scenes… biology is one of the key components… blood dynamics, that sort of bridges between biology and physics … things like surface tension and viscosity and all these sort of terms that are related to physics that's certainly related to the way blood behaves and therefore influences the way you interpret blood stains at the scene… A little bit of maths may be involved in some blood splash scenes … (PP6, p. 10).

In summary, the nature of particular field forensic applications such as blood pattern analysis requires the interdisciplinary approach. However, laboratory practice demands multidisciplinary education where practitioners become specialised in one scientific discipline.

5.2.3.3- Curricular Approaches through which Forensic Science Knowledge is to Be Organised as Asserted by the Third Group Participants.

Participating members of associated professions held various informed opinions about the curricular approach appropriate for forensic science.

> *The interdisciplinary approach may be appropriate for someone who is a specialist crime scene examiner, but certainly not for the person who actually might be doing later analysis in the laboratory as this person needs to be more specialised … forensic science is such a broad field … what's the point of having a person to be half an expert in chemistry, biology, this and that, when all they're really going to do is probably just one narrow field…*(AP2, p. 14).

> *I guess that the interdisciplinary approach might have a good deal in the field… a multidisciplinary approach might be an important beginning but I would have thought that there has to be an integration between the departments to provide specialist skills... I would have thought that there has to be a blend of both curricular approaches* (AP4, p. 14).

In summary, the third group participants expressed divided opinions on the curricular approach needed to organise forensic science education. These opinions varied from an interdisciplinary approach for forensic knowledge towards field practices, a multidisciplinary approach for knowledge directed towards laboratory practices, to a mixture of the two approaches in the one curriculum.

5.2.3.4- Summary of the Third Category of Description

All of the first group participants agreed that the multidisciplinary approach is the curricular approach which needs to be adopted to organise forensic science education. Through this approach, students explore forensic science from various lenses but they finally specialise in the one science discipline.

There was consensus amongst all second group participants about the need for an interdisciplinary approach to organise the education and training for forensic field applications which draw on a number of disciplines. However, laboratory practitioners argued that their education needs to be mainly organised through a multidisciplinary approach as they need to be specialist in the major discipline employed by their laboratory (e.g. chemistry for a forensic chemistry laboratory and biology for a forensic biology laboratory).

Opinions of third group participants distribute between the adoption of specific curricular approaches for specific type of forensic practices versus the adoption of a mixture of curricular approaches in the one curriculum.

5.2.4- Category 4: Pedagogies Required to Emphasise Forensic Science Knowledge

In this category, the research identified the various teaching approaches which are required to emphasise forensic science knowledge as asserted by the three groups of participants in the course of their interviews.

5.2.4.1- Pedagogies Required to Emphasise Forensic Science Knowledge as Argued by the First Group Participants

Choice of Teaching and Learning Strategies

Interviewed forensic science educators asserted their preferences for teaching approaches which best emphasise forensic science knowledge. They stressed that course delivery should comprise a combination of different teaching strategies which responds to different learning needs and emphasises a range of the essential forensic science skills:

> *Pedagogy that may be followed in delivering a course may be a combination of lectures, workplace learning, workshops, reading and/or assignment-based... I mean really it can be a mixture of all them, a whole spectrum of different learning styles. Any course has to deliver things in different ways, because different people will learn in different ways... and different skills are recognised via different strategies* (EP1, p. 7).

EP1 argued that the teaching strategy which best promotes students' communication skills is through moot court room presentations where 'participants are given a crime scenario and they're requested to write a set of case works like a statement and also perform a presentation… where real judges sit on the bench, real barristers at the Bar table and each of the participants is examined and cross-examined on that statement, on the work that is supposed to have been done, and they're given feedback as a result of that' (EP1, p. 7). However a number of participants (EP1 and EP2) argued that in forensic science there exist a number of areas which cannot be delivered through a conventional classroom setting but only through practice-based learning setting. For instance, 'blood pattern analysis can only be covered through on-the-job training' (EP2, p.2).

Learning Strategy for Novice Practitioners

Training for novice practitioners is mainly delivered through "learning by observation" followed by learning through experimenting.

> *We give a rundown of the facility here and what kind of work we do so they would have an appreciation of that… so we give a lot of background information, so they have an appreciation of it all, then we do have a practical session and we demonstrate first then we ask them to do it, and we check on how well they're doing it and we hold them up from time to time and talk about it…* (EP4, p. 8).

Summary

In summary, the first group participants argued that teaching and learning in forensic science is best done via a combination of learning strategies which both emphasises the range of essential forensic science skills, and responds to the different needs of different students. However, there exist specific forensic forms of inquiry which may not be delivered within a university course of study, but only through on-the-job training. Training of novice practitioners often starts with learning by observation then by doing. Background information and theory are provided to trainees before they start practical training.

5.2.4.2- Pedagogies Required to Emphasise Forensic Science Knowledge as Argued by the Second Group Participants

Learning by Observation

There was consensus amongst the second group participants that uniquely forensic forms of inquiry (e.g. crime scene investigation, fingerprinting, and blood pattern analysis) are mainly acquired through on-the-job training and practice-based learning, where novice practitioners are exposed to hundreds of scenes. Learning commences by observation when trainees accompany senior practitioners in their domains. Trainees "shadow" the senior practitioners for a period of time before trying things themselves up until they become qualified and accredited to work independently.

> *Your training involves a 5-years in-service training course. Over those 5 years, you have to learn the skills involved in crime scene examination, photography, basic blood splash, as well as the dynamics of firearm discharge and the technical side of firearms. That period also includes the expertise you gain in giving evidence in court, so that at the end of the five years, the competencies acquired through that in-service training course allow you to present evidence, examine scenes, identify fire cases and ballistics… At the early stages, most of the training is done through accompanying and observing qualified practitioners whilst working in the field and at lab, then trainees start trying things themselves. What occurs is that at various stages of your training you gain competencies for which you can be authorised to report on to certain cases* (PP1, p. 6).

> *We started our training by going out to crime scenes as a team of three, and there's always a senior crime scene examiner there. We start off in the photographic field… you're observing, you're seeing what the examiner is recording, what he's looking for, what he's taking photos of, so you get an understanding of what's important here, what's necessary to record… purely for 2 years, then you get moved on to a point when you now become his assistant, next to his bags, do his measurements, do some sketches and that type of stuff. So he's still commenting on the scene, but you're doing some leg-work … then after experiencing hundreds of scenes, you sit exams, some boards, present your work, and if you satisfy all the criteria then you're authorised, and then you're the*

senior crime scene examiner, and you'll be going out to scenes heading teams with a junior photographer and another person, assisting you… (PP2, p. 7).

Forensic Areas which Require Practice-Based Settings

Laboratory practitioners appreciated pedagogies adopted within their universities in their prior education. However, they asserted that there are specialised forensic areas, such as blood pattern analysis, which cannot be acquired in a university setting.

> *My prior education [honours degree in biology] is vital to my current position and everyday practice, but there are such specialist areas like bloodstain pattern interpretation that you're not going to get education in that at university, it's really once you get into the job, then you start exploring it and learning it within context… you always come across with plenty of different scenarios that can be complex … so just exposure over time to the different circumstances and obstacles you'll face on every crime scene and the ways you challenge those obstacles is really the most important thing to build on your competency… I think blood is such a unique fluid, you have to sort of basically start from scratch with these terms in learning about blood in that context, I mean certainly I'd heard terms like viscosity and surface tension back at university but not in the context of blood pattern analysis, you'll only learn that within context on the job* (PP6, p.8).

Summary

In summary, there was consensus amongst all practitioners that uniquely forensic forms of inquiry cannot be acquired in a university setting but only in a practice-based setting. Learning on the job first starts by 'observation', then 'doing', and is finally assessed through passing a number of boards and examinations.

5.2.4.3- Pedagogies Required to Emphasise Forensic Science Knowledge as Argued by the Third Group Participants

Members of associated professions did not express particular opinions in regard to how best to emphasise forensic science knowledge. However, interviewees of this group asserted the importance of acquiring forensic competencies through experience.

5.2.4.4- Summary of the Fourth Category of Description.

The first group participants stressed that the delivery of a forensic course of study requires a combination of different teaching approaches for a number of reasons. First, a single pedagogical approach is unable to emphasise all required knowledge elements and competencies. Second, the pedagogy which might work for one student, might not work for another. Third, in forensic science, there exist uniquely forensic forms of inquiry which may not be delivered within a university setting, but only through a practice-based setting. The participating educators also stressed that novice practitioners start learning by observation and then by experimenting.

The second group participants argued that uniquely forensic forms of inquiry may only be acquired through on-the-job training and practice-based learning. This is because the workplace context cannot be replicated in a university setting. Learning in this case commences by observation before trainees try things themselves up until they become qualified and accredited.

Third group participants did not stress any specific pedagogical approach. However, they emphasised that the acquisition of forensic skills and competencies is best done within an experiential setting.

5.2.5- Category 5: Differentiation between the Knowledge-base and Competencies of Forensic Science Experts with Tertiary Education and Those Without.

In this category, the research detected reported differences in the knowledge base and competencies between experts with tertiary science qualifications and those without as emphasised by the participants' perceptions and viewpoints.

5.2.5.1- Differences in Forensic Science Knowledge base and Competencies between Experts with Tertiary Education and Those Without as Reported by the First Group Participants.

Participating educators agreed that practitioners with a science background possess a deeper and more thorough scientific understanding than those without. However, this does not necessarily make them any better or any worse than their colleagues who do not hold tertiary qualifications. Practitioners' performance is directly proportional to their competencies and experiences.

> *Police witnesses [forensic practitioners who are sworn police members] are more used to being in court than do civilian witnesses, because they've been showing up in court for many years in their general policing duties. The environment is not as strange to them as it is to some of the scientists. As far as how they answer the questions and their depth of knowledge, it's a bit like trying to compare apples with oranges in some ways. The scientist obviously does have more depth to their knowledge but then one does expect that, the police on the other hand can sometimes put things more in context than the scientist, because they're used to seeing things in that way...* (EP1, p. 10).

On the other hand, participants argued that if the science background is supported by experience then this result in a successful combination.

> *A science degree would be very complementing with the forensic work when nurtured with experience* (EP1, p. 10).

> *If someone has the context, the qualification, and the background, then that's a winning combination* (EP2, p. 10).

Participants also asserted that practitioners with scientific backgrounds often perform much better than those without formal qualifications in complicated forensic science cases and in matters relating to research and development:

> *I personally have no doubt that if you get people who have the context, contextual experience, but also have the underpinning scientific basis...they will be better in those unusual forensic science cases... It will make a difference in those cases [complex cases] and perhaps in some innovative research back at the laboratory …* (EP2, p. 10).

Practitioners with scientific backgrounds perform much better when it relates to research and development in forensic science, and when it comes to handling complicated and unusual cases which require advanced techniques, approaches, and methods … (EP4, p. 10).

In summary, the first group participants stressed the necessity that forensic practitioners hold tertiary science qualifications. However, they argued that there is no point in holding high academic qualifications if practitioners are unable to apply scientific knowledge within practical contexts. Practitioners with tertiary science education often perform better than those without specifically in complicated cases and in the area of research and development.

5.2.5.2- Differences in Forensic Science Knowledge base and Competencies between Experts with Tertiary Education and Those Without as Reported by the Second Group Participants.

Participating field practitioners did not report any major differences between practitioners with and those without a science background, for two main reasons. First, knowledge and expertise in their areas- according to their stance- are mainly acquired through workplace learning and years of experience. Second, the knowledge base they apply in their everyday practice is not science on the speciality level, but rather on a basic or technical level. This stance is reflected in the following excerpts.

No it wouldn't be an advantage [to hold a science degree] but it would be an interesting thing to have… all the physics wouldn't help you with the mechanical side of firearms identification… the only part that is of interest to the courts is the end result of the analysis like: "Yes the firearm fired that bullet, that bullet was found in the deceased"… (PP1, p. 6)

You certainly don't need a degree [to practice as a CSI]; it helps, I believe that helps me in terms of understanding the physical world we're in, and what's possible and what's not possible, particularly like a guy who is a farmer who knows how tools work and how natural phenomena like lightning and rain happen … The best examiners that we have here don't hold science degrees.

> *They've got a practical mind, they are methodical, they have the right attitude they're not lazy…* (PP2, p.8).

On the other hand, participating laboratory practitioners expressed opinions which complemented those of field practitioners on the importance of gaining experience and acquiring competencies through workplace settings. However, they emphasised that it is a requirement to hold a tertiary science degree in order to practice in the forensic laboratories.

> *you can never work here [chemistry laboratory] and just have that, I don't think so, that's why I could only join the lab here at a junior position and I am currently undertaking a tertiary degree in chemistry which will assist me in promoting to more senior positions within the lab* (PP5, p.8).

In summary, participating field practitioners did not attribute any major advantages in holding a tertiary science degree. On the contrary, laboratory practitioners asserted the importance of holding tertiary science qualifications, specifically in the laboratory practice.

5.2.5.3- Differences in Forensic Science Knowledge base and Competencies between Experts with Tertiary Education and Those Without as Reported by the Third Group Participants.

The third group participants showed consensus on the importance of experience which is a priority that precedes the importance of possessing tertiary education. This is evident from the following excerpts:

> *I don't think as a police officer, when you're seeking the service of forensic scientists that you're particularly concerned in exactly what their tertiary qualifications are... Certainly from a police point of view, a number of forensic science fields don't necessarily, in my opinion, require tertiary qualification. There are certainly some fields where people can be experts through experience, like in the areas of firearms and tool marks, where the leading experts are generally police officers* (AP2, p. 1).

> *The important thing is that the scientist has the necessary expertise and that can be acquired through experience, through study of a very narrow field perhaps of scientific research or experience, or it may require a very significant academic background...* (AP4, p. 2).

In summary, the third group participants emphasised that whilst certain forensic areas require tertiary education, other areas of forensic science require learning from experience.

5.2.5.4- Summary of the Fifth Category of Description.

The first group participants argued that practitioners' performance in the field is directly proportional to their experiences, but not necessarily to their academic background. However, if the science background is nurtured with experience and communication skills, then this is a very proficient combination. Participants asserted that practitioners with scientific backgrounds and sufficient experience often perform much better than those without tertiary education specifically in approaching complicated forensic science cases and in the area of research and development.

As for the second group participants, participating field practitioners emphasised that experiential knowledge and competencies gained through years of practice are much more important than any scientific tertiary qualifications. On the other hand, participating laboratory practitioners asserted that experience is very important in their work; however, science education is as vital for their practice.

The third group participants argued that whilst a science degree is a prerequisite in certain forensic areas, experience and ability to communicate results precede any requirement of possessing tertiary education.

5.3- Inter-categorical Analysis

Subsequent to 'categorical coding', where five conceptual knowledge categories had been identified, inter-categorical analysis was implemented across the perceptions of the three groups of participants in each of the five identified categories. This strategy allowed the observation of each categorical knowledge conception not only from the perspective of each individual participating group, but also as the summation of the perceptions and experiences of the three groups of participants (Marton, 1981). It also allowed the generation of inter-categorical knowledge attributes.

Such analysis across the stances of the various groups of participants in each category, allowed the development of each category, the comparative exploration of the coded data, and alertness to new messages and themes (Richards and Morse, 2007). In doing so, the research adopted Pinar's position from the curriculum as being a "complex conversation" between the various stakeholders concerned with such curriculum (2004), where inter-categorical analysis is nothing but a complex conversation between the perceptions of each of the three groups of participants.

5.3.1- Inter-Categorical Analysis across the First Knowledge Category of Description

Inter-categorical analysis across the first knowledge category compared the various education backgrounds and knowledge base of the three participating groups: a) educators, b) practitioners, and c) members of associated professions. Tables 5a, 5b, and 5c respectively summarise the educational backgrounds and competencies of the participating educators, practitioners, and members of associated profession. Tables 5a and 5b also show how participants acquired their forensic science knowledge and competencies.

	Education Background	Source of Forensic Science Knowledge
EP1	Master's of Biology	Subsequent to employment by a forensic science agency
EP2	PhD in Chemistry	Subsequent to employment by a forensic science agency
EP3	PhD in Forensic Science (Forensic chemistry)	Through university and research
EP4	PhD in Biology	Subsequent to employment by a forensic science agency

Table-5a

	Expertise	Education	Source of forensic science knowledge
PP1	Field Practitioner	Police Academy & Internal Training	Subsequent to employment by a forensic science agency
PP2	Field Officer	Science Degree, Police Academy & Internal Training	Subsequent to employment by a forensic science agency
PP3	Laboratory Practitioner	Biology Degree & Internal Training	Minor exposure through the honours year and major acquisition subsequent to employment by a forensic science centre
PP4	Field Practitioner	Apprenticeship in mechanics, Police Academy, & Internal Training	Subsequent to employment by a forensic science agency
PP5	Laboratory Practitioner	Forensic TAFE degree, Chemistry Degree & Internal Training	Peripheral acquisition of forensic knowledge through TAFE and major acquisition subsequent to employment by a forensic science centre
PP6	Laboratory Practitioner	Biology Degree & Internal Training	Minor exposure through the honours year and major acquisition subsequent to employment by a forensic science centre

Table-5b

	Field of Association	Expertise
AP1	Psychology	Forensic Psychologist
AP2	Police	Senior Detective
AP3	Law	Barrister: Defence
AP4	Law	Barrister: Defence & Prosecution

Table- 5c

Participating forensic science educators generally acquired their specific forensic knowledge base, skills, and competencies subsequent to their employment in a forensic science agency/centre. Prior to that, their formal postgraduate research qualifications provided them with minor exposure to forensic science, whilst researching one of the main streams of science (molecular biology or analytical chemistry) vital to the forensic work. Similarly, laboratory practitioners-prior to their employment- acquired either minor or peripheral forensic science knowledge during the term of study at their education institutes, where the main focus of their courses was one of the specialised science fields. For instance, practitioners PP3 and PP6 were exposed to some of the forensic techniques whilst conducting their honours research at university in collaboration with a forensic science laboratory. However, all participating practitioners attribute the acquisition of the majority of their forensic science knowledge and competencies to the training courses undertaken, workplace learning undergone, and long term experience acquired at their workplaces.

Differences in education backgrounds can be noticed between laboratory practitioners on the one hand, and laboratory practitioners on the other, where the first generally possesses higher level of education (tertiary) than the second.

The backgrounds of all the three groups of participants show the various types of professions/areas which are associated with the forensic field.

5.3.2- Inter-categorical Analysis across the Second Knowledge Category of Description

The nature of forensic science knowledge (experiential versus theoretical) was an issue of debate between the participants, particularly the second group participants. This issue will be explored and analysed in more details in the following section (section-5.4: cross-comparison synthesis). In this section, inter-categorical analysis across the second knowledge category compared and contrasted the various perceptions across the three participating groups in regard to the required knowledge base and competencies within the forensic profession. Table-5d summarised direct quotes which show each group's position from the knowledge base which needs to be incorporated in forensic science education.

Participating Educators	Participating Laboratory Practitioners	Participating Members of Associated Profession
***To be a forensic scientist ... one needs to be a scientist- a good scientist* (EP1, p. 3).**	***Biology is number one... we speak of the various biological techniques* (PP3, p.4).**	***I want forensic scientists to be good scientists, specialists in their fields* (AP1, p.1).**
***Forensic scientists have to know enough about science.* (EP2, p. 4).**	***The majority of our work is based on biology* (PP6, p. 6).**	***Forensic practitioners need to be proficient scientists because at the end of the day science is what they are delivering to courts* (AP3, p. 2)**

Table-5d

Table-5d showed that there was consensus amongst all participating educators, all participating laboratory practitioners, and the majority of the participating members of associated professions that any forensic science education should emphasise a strong science knowledge base. This is because for an individual to become a proficient forensic scientist, he/she must be a proficient scientist first and foremost (EP1, EP2, EP3, EP4, PP3, PP5, PP6, AP1, AP3, and AP4). On the other hand, the participating field practitioners argued that they either do not apply science in their work or they only apply crude and basic science: 'we don't use physics' (PP1, p. 3); 'it's not rocket science' (PP2, p. 3); 'it is very basic science' (PP4, p. 5). This position adopted by those practitioners, who generally lack tertiary science education, was highlighted by educator EP2 who asserted that such practitioners do unknowingly apply science and scientific principles in everything they do.

> *People who don't realise that things like firearms, they learn about lams and grooves and which can fire what… but they also do the chemistry, they use science to determine range, how far away, they use chemistry to do the analysis of the gun-shot residue …* (EP2, p. 4).

In their comment on the inclusion of a forensic science component within a forensic science course, participating educators warned that such an introduction should never be at the expense of the science component. Forensic knowledge may be acquired later on through on-the-job training, whilst scientific understanding may not be.

In addition to the heavy specialised science component and the forensic science component, there exist other knowledge components and competencies vital to forensic science practice. These knowledge components and competencies were emphasised by the various groups of participants and are summarised in Table-5e.

Additional Knowledge Components and Competencies				
no. of participants emphasising the component or competency	**Legal Knowledge**	**Statistics**	**Communication Skills**	**Critical Thinking**
1st group participants	3 of 4	None	4 of 4	**4 of 4**
2nd group participants	4 of 6	3 of 6	6 of 6	**4 of 6**
3rd group participants	None	None	4 of 4	**3 of 4**
Overall emphasis	**7 of 14 (50%)**	**3 of 14 (21%)**	**14 of 14 (100%)**	**11 of 14 (79%)**

Table-5e

Knowledge of the legal system was emphasised by the majority of the first and second group participants. However, it has not been asserted by participating members of associated professions. Third group participants, specifically the participating barristers, AP3 and AP4, did not regard legal knowledge as essential, because what was really essential- from their perspective- is the practitioners' knowledge and analysis of science, not that of law.

This conflict between the opinion of the participating educators and practitioners, and the opinion of the participating barristers invites Bernstein's notion of the social groups, where each social group has its preferences in representing the knowledge related to their fields.

Despite such conflict, knowledge of the legal system, as emphasised by the majority of educators and participants, comes secondary to the scientific and forensic knowledge. Such knowledge is not supposed to be in depth as is required by legal practitioners, but sufficient enough to enable forensic practitioners to: a) operate in sufficient understanding of the acts and laws governing their practice, b) understand where they fit in the whole judicial procedure, and c) appreciate the value of the evidence presented to a court of law.

Thorough knowledge of statistics was emphasised by laboratory practitioners. Those practitioners asserted that statistics is vital for proving the validity and reliability of their evidence (e.g. showing that error in the match in the DNA profile between a crime scene exhibit and a suspect is nearly zero or insignificant).

The importance of communication skills- both written and oral- enjoyed consensus by all participants because "despite the primary necessity for a forensic scientist to be a good scientist, there is no point of being a good scientist if you are unable to properly communicate your results to a vast range of audiences including judges, juries, prosecution, and defence" (EP2, p. 6).

Critical thinking was regarded by the majority of participants as vital for forensic practice as forensic practitioners "must be able to think critically … to look outside the box… to look at complex issues and problems" (EP3, p. 7) and be able to "critically interpret things and link evidence to a potential suspect" (PP4, p. 5).

As a summary, the majority of participants regarded scientific knowledge as essential for any forensic practice, regardless of whether it is a field or laboratory practice. On top of the scientific knowledge, acquiring specific forensic knowledge is vital. However, this acquisition should not exist at the expense of science education in a course of study. The majority of the participants emphasised moderate legal knowledge and critical thinking as necessary for forensic science practice. All practitioners stressed the importance of communication skills in the forensic science field.

5.3.3- Inter-categorical Analysis across the Third Knowledge Category of Description

Inter-categorical analysis across the third knowledge category compared and contrasted the various perceptions across the three participating groups in relation to the curricular approach required to set and organise forensic science knowledge. Table-5f summarises each group's position from the curricular approach needed to organise forensic science education.

Curricular Approach	Multidisciplinary	Interdisciplinary
Educators	Consensus amongst all participants that multidisciplinary approach should be followed	One educator (EP3) asserted that interdisciplinary approach may be followed to teach some forensic subjects
Practitioners	The approach to be followed to be a specialist in one of the vital science streams for forensic science (e.g. forensic chemistry and forensic biology).	The best approach for teaching and learning uniquely forensic forms of inquiry.
Members of Associated Professions	Multidisciplinary approach for personnel seeking laboratory practice.	Interdisciplinary approach for in the field applications.

Table-5f

The majority of participants amongst all three groups asserted that the most appropriate approach to be adopted to organise and emphasise forensic science knowledge in higher education is the multidisciplinary approach. Nevertheless, there are specific forensic areas and competencies, such as crime scene processing and blood pattern analysis, which are better delivered through an interdisciplinary approach because such areas/competencies require crossing-over and employment of a number of disciplines to be able to perform the one task.

5.3.4- Inter-categorical analysis across the fourth Knowledge Category of Description

Inter-categorical analysis across the fourth knowledge category contrasted the various perceptions across the groups of participants in relation to the pedagogy required to emphasise forensic science knowledge. Table-5g summarises each group's position with respect to this conception.

Various perceptions existed amongst various participating groups towards how best to emphasise forensic science knowledge. It may be summarised that the best pedagogy needed to emphasise forensic science knowledge in higher education is a combination of different teaching approaches (e.g. LBL, PBL, etc) with moot court presentation to explore communication skills, taking into account practice-based learning for those areas which may not be covered in a classroom setting. As for the pedagogies adopted to train novice practitioners, participants argued that learning starts by observation where new trainees observe experienced practitioners performing specific tasks, and then they learn by performing these tasks themselves.

	Higher Education Students	**Forensic Science Trainees**
Educators	A combination of different teaching strategies (EP1, EP2, and EP3).	Learning by observation followed by learning through experimentation (EP4).
Practitioners	LBL to theoretical component and practice-based learning to those areas that cannot be covered in a classroom setting (PP3, PP5, and PP6).	Learning by observation followed by learning through trying (Consensus amongst all participants).
Members of Associated Professions	Learning through experience (AP1 and AP2).	Learning through experience (AP1 and AP2).

Table-5g

5.3.5- Inter-categorical Analysis across the Fifth Knowledge Category of Description

Inter-categorical analysis across the fifth knowledge category compared the various perceptions across the different participating groups in relation to reported differences (if any) in the skills and knowledge base of practitioners with tertiary education and those without. Table 5h summarises each group's position from any observed differences in this respect.

	Reported Differences in Skills and Knowledge Base between Practitioners
Educators	Practitioners with tertiary education and sufficient experience are a 'winning combination' (EP1 and EP2).
Practitioners	Field practitioners do not attribute any major advantage to tertiary education, only to practical experience (PP1, PP2, and PP4). Laboratory practitioners emphasise both tertiary education and practical experience as vital for their work (PP3, PP5, and PP6).
Members of associated professions	Third group participants agree that whilst a science degree is a prerequisite in certain forensic areas, experience and ability to communicate results is a priority over tertiary qualifications (AP2, AP3, and AP4).

Table-5h

In summary, the majority of participants across various groups agreed that the most proficient combination is when a practitioner possesses both tertiary science education and practical experience.

5.3.6- Summary of the Inter-categorical Conceptual Attributes across the Five Conceptual Knowledge Categories.

The inter-categorical conceptual attributes arising from the inter-categorical analysis across the four categories of description are summarised in Table-5i.

Summary of the Inter-categorical Knowledge Conceptual Attributes	
1st Category of Description	The backgrounds of the participating practitioners show differentiation between field practitioners on the one hand, and laboratory practitioners on the other.
	The backgrounds of all three groups of participants represent the variety of the fields, domains, and professions which are incorporated within or associated with forensic science.
2nd Category of Description	Forensic science is both experiential and theoretical in nature
	Forensic science tertiary education needs to emphasise a strong science knowledge base on top of which the forensic science component may be added.
	Forensic science education/ training needs to emphasise moderate legal and statistical knowledge and a range of essential forensic science skills (communication, critical thinking, etc)
3rd Category of Description	Forensic science education at tertiary level is more of a multidisciplinary nature, whilst in-service forensic education/ training is more of an interdisciplinary nature.
4th Category of Description	Forensic science knowledge needs to be emphasised via a combination of different teaching approaches, taking into account practice-based learning for those areas which cannot be covered in a classroom setting and learning via observation for new trainees.
5th Category of Description	Despite the non- consensus between field and laboratory practitioners, the majority of the participants argue that the most proficient combination in forensic practice is a combination of tertiary science education and practical experience.

Table-5i

5.4- Forensic Science Knowledge: A Cross- Categorical Synthesis

Following inter-categorical analysis, cross-category synthesis across the identified inter-categorical attributes took place in order to identify:

a) themes relating to the nature of forensic science knowledge,

b) a general set of exemplars reflecting forensic science knowledge, and

c) implications for forensic science education which respond to the nature of forensic science knowledge and emphasise the identified knowledge exemplars.

Cross-comparison synthesis was conducted across the identified knowledge categories of description to generate four themes relating to forensic science knowledge. Each of the identified themes was generated following a discourse between at least two inter-categorical knowledge attributes emerging from different categories of description. In doing so, the research adopted Bernstein's pedagogic device (2000), where themes were only identified after the recontexualising and reconceptualising of the identified inter-categorical attributes. An example demonstrating the pedagogic discourse which took place between the inter-categorical knowledge attributes of the first, second, and third categories of description to generate theme1 is presented in Figure-5b.

The four identified themes pertained to participants' perceptions of forensic science knowledge. These themes provided insights into the nature of forensic science knowledge and the education which may respond to and reflect upon such a nature. These insights form an essential aspect of the major research question.

Further exemplification of each of the identified themes resulted in a set of four knowledge exemplars. Finally, the research identified implications for forensic science education which reflect the nature of forensic science knowledge and emphasise the identified knowledge exemplars.

For enhancing the readability of the thesis and ease of referring to the identified inter-categorical attributes in section 5.3, the research adopted the abbreviation of inter-categorical analysis of the first, second, third, fourth, and fifth categories of description to IC1, IC2, IC3, IC4, and IC5 respectively.

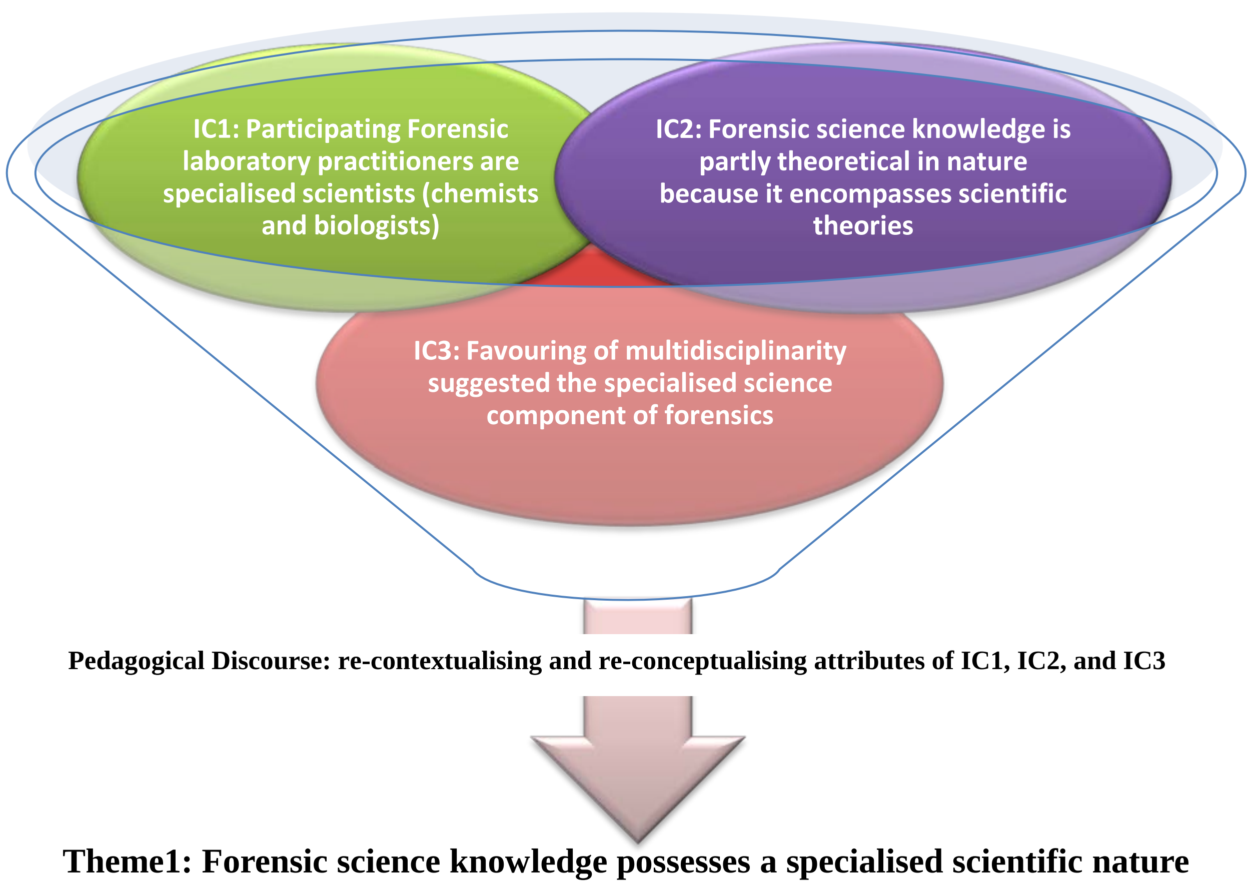


Figure-5b

5.4.1- The Nature of Forensic Science from a Knowledge Perspective

Themes that meet specified criteria are reported in this section. The criteria for reporting the themes constituted three conditions:

1. The theme is not specific to any one perception of an individual participant or an individual group of participants.
2. The theme is generated following pedagogic discourse between at least two inter-categorical conceptual attributes emerging from different categories of description.
3. The theme is significant with respect to the major research question and supplementary research questions.

<u>Theme 1: The Specialised Scientific Nature of Forensic Science Knowledge</u>

Different views on the nature of forensic science knowledge existed (IC2). However, the pedagogic discourse which was conducted between attributes of IC1, IC2, and IC3 emphasised that the nature of forensic science knowledge is of a specialised scientific nature to a great extent. This is suggested by the following attributes:

a) Forensic practice comprises specialised scientists (e.g. PP3 and PP6) (IC1),
b) Forensic science knowledge is partly theoretical in nature because it encompasses scientific theories (IC2),
c) The specialised science nature of forensic science has pushed the majority of the participants to favour multidisciplinarity over other curricular approaches, where students observe forensic science using a number of lenses; however, they ultimately apply the one discipline in their final learning approach (IC3).

Hence, forensic science practitioners, despite their specialisations, need to possess a strong science background for two main reasons:

1. Forensic practitioners, first and foremost, are scientists (IC2) despite the fact that many field practitioners 'unknowingly apply science in mainly everything they do' (EP2, p.4). For example, firearms and ballistics examiners 'don't realise' that they are using science (e.g. physics) to determine the range of a

bullet in a shooting case (EP2, p.4). Moreover, scientific concepts are not only vital for laboratory practice, but also are essential for field practice because problem solving in forensic investigation depends on the understanding of these concepts (Caddy, 2000).

2. Generally speaking, field practitioners are often police officers (Horswell, 2004) who do not hold tertiary degrees in science such as PP1 and PP4 (IC1). Hence, they are less 'scientifically and academically' educated than their laboratory counterparts (NIFS, 2006). These deficiencies in science education have resulted in weaknesses in both the understanding of scientific concepts and the use of scientific methodology demonstrated by forensic science practitioners (Wood, 1997). This has pushed a number of countries to develop diploma degrees in forensic investigation by independent tertiary education providers to educate forensic practitioners particularly field practitioners (Horswell, 2004). With the emergence of more scientific and technical challenges in forensic science, many senior managers of forensic laboratories have stressed the necessity to raise the level of qualification required for police forensic staff to degree level by the year 2010 (NIFS, 2006).

Therefore, forensic practitioners, despite their speciality areas, need to be equipped with a solid science background. Within this science background, practitioners need to be specialists in only one scientific discipline (IC2 & IC3).

> *You want people with specialist background in each of those… you need someone capable of doing a specialty task (*EP4, p. 6).

> *I want forensic scientists to be good scientists, specialists in their fields* (AP1, p.1).

<u>Theme 2: The Vocational Nature of Forensic Science Knowledge</u>

Forensic science knowledge is also vocational in nature. This was suggested by the discourse which was conducted between IC1, IC2, IC3, and IC4:

a) Forensic practice comprises field practitioners of vocational background (e.g. PP1 and PP4) (IC1),
b) The vocational nature of forensic science knowledge is reflected in the emphasis of a number of practitioners that:
    - Forensic science is partly experiential in nature (IC2)
    - Forensic science is best acquired through an interdisciplinary curricular approach (IC3) in a practice-based learning setting (IC4).
    - Practical experience takes precedence over formal education in the forensic work (IC5).

This vocational nature of forensic science knowledge seems to be more apparent in forensic field practice than in laboratory practice.

<u>Theme 3: The Legal Nature of Forensic Science Knowledge</u>

Forensic science knowledge possesses a legal nature, as the ultimate purpose of all knowledge base, sciences, and applications incorporated within forensic science is to pertain to law (Camenson, 2001; Bell, 2004; Horswell, 2004; Tilstone et al., 2006). Such nature was suggested through the discourse which took place between attributes of IC2, IC3, and IC4:

a) The emphasis of the majority of the participants on the need of acquisition of moderate legal knowledge in addition to the forensic science knowledge base (IC2),
b) The stress by a number of participants on the importance of adopting an interdisciplinary curricular approach for forensic science knowledge which facilitates integration of various disciplines within the one legal context (IC3),
c) The emphasis on moot-court presentations as one of the key teaching approaches of forensic science (IC4).

Such legal nature is the reason behind the emphasis of all participants on the importance of communication skills. This is because there is no value for any knowledge or experience if such knowledge and experience cannot be translated within legal contexts which are acknowledged by the judicial system and understood by the range of audiences comprising the elements of a trial (judge, prosecution, defence, and jury).

Theme 4: Essential Forensic Science Skills

In addition to the scientific knowledge (Theme 1) and vocational knowledge (Theme 2) which comprise forensic science knowledge, there exist a number of skills essential to everyday forensic practice. These skills include critical thinking and communication skills. (IC2). Such skills comprise one of the factors behind the need for a combination of teaching approaches to emphasise forensic science knowledge (IC4).

In summary, this subsection identified four themes relating to forensic science knowledge. Forensic science knowledge possesses a scientific and vocational nature. It also possesses a legal aspect. In addition to the scientific and vocational components, forensic science knowledge comprises a number of essential competencies.

5.4.2- The General Set of Forensic Knowledge Exemplars

To create a theoretical framework which interconnects knowledge, methods, applications, techniques, and skills within forensic science, the research adopted Kuhn's concept of "exemplars" (1996). Anyone who studies a scientific discipline is anticipated to acquire its exemplars (Kuhn, 1996). Hence, the research attempted, in this section, to identify a general set of exemplars which emphasises features of forensic science knowledge.

The research identifies a general set of four knowledge exemplars (Table-5j) which may be used amongst:

- Forensic science educators and course coordinators to identify features of forensic science knowledge and the way(s) to emphasise such features in a curricular approach, and

- Forensic practitioners to subscribe to an interconnecting framework of knowledge and competencies.

Each of the identified four exemplars portrayed one of the themes identified in subsection 5.4.1. Each exemplar added a practical component to the theme from which it emerged.

Identified Exemplar	Portrayed Theme
Exemplar 1: The Scientific Component of Forensic Knowledge	Theme 1
Exemplar 2: The Vocational Component of Forensic Knowledge	Theme 2
Exemplar 3: The Legal Component of Forensic Knowledge	Theme 3
Exemplar 4: Essential Forensic Capabilities	Theme 4

Table-5j

<u>Exemplar 1</u>

Forensic knowledge comprises theories, principles, and concepts in mathematics, chemistry, biology, and physics which underpin most activities in forensic science (Caddy, 2000). Because forensic practitioners need to be specialised, forensic science practitioners need to possess a specialised science discipline, where they apply theories and concepts of such discipline in most of the activities they conduct. In addition, they need some general science background to assist them in conducting their activities.

The nature of each forensic area or profession determines the nature of the "specific science component" and the "general science component" required for that specific area/profession. Once, a specific science component is identified for a specific forensic area, the remaining science disciplines become the “general science component” for this specific area. For example, forensic chemists need to be mainly specialised in chemistry which is their specialised science component, although they have to be aware of the associated science disciplines such as biology, physics, and mathematics which comprise their general science component. This was reflected by the perception of practitioner PP5, who is a forensic chemist:

> *Definitely chemistry; biology no; not every day; we have to have a knowledge of what they do, in order to not contaminate items with DNA... physics a little bit, only in the instrumentation part of things… we use a bit of mathematics …* (PP5, p.5).

The same applies to forensic biologists who need to be mainly specialised in biology although they have to be aware of associated science disciplines (e.g. chemistry, mathematics, etc) which comprise their general science component. This was emphasised by the perception of practitioner PP3, who is a forensic biologist:

> *Biology is number one and we speak of the various biological techniques … I guess there can be a little bit of chemistry, mainly crude chemistry… we might be mixing a few chemical reagents prior to use...* (PP3, p.4).

Statistics comprises one of the disciplines that are needed in the forensic science work. This discipline becomes more important in forensic laboratory areas which require statistics to show the significance of the forensic analyses (IC2). For example, in the forensic biology area, practitioners are required to prove that the identified match between the DNA profile of a collected exhibit (e.g. hair, blood stains, saliva, etc) and that of a suspect is beyond any reasonable doubt; that the probability that the identified exhibit belongs to an individual other than the suspect is nearly null.

<u>Exemplar 2:</u>

The vocational component of forensic science comprises ‘uniquely’ forensic forms of inquiry (e.g. crime scene investigation, firearms, fingerprinting, hand written examination, etc) which may only be acquired through workplace learning and experience. For example, PP4, who is a forensic vehicle examiner, described in one of his experiences how one of the scientists, who lacked vocational knowledge in mechanics, failed to manage his unit (The Vehicle Examination Unit):

> *For instance, my previous supervisor, who came down from chemical trace evidence, was a scientist and had no knowledge in motor vehicles. He went about trying to merge some of the procedures, to improve new methods and different chemicals for testing... but he lost the sight of the fact that the car is the most important focus especially as I said with some cases, some crooks they don't use a lot of techniques, they'll avoid leaving evidence behind them that we can treat with chemicals, in these cases you've got to identify the cars and you've got to be able to back transfer these other principles [mechanics]… he [supervisor] struggled and basically he isn't here anymore. He didn't do enough case-work, didn't contribute that much to the team because of his lack of knowledge in motor vehicles… in the selection process definitely those with tertiary qualifications would probably get the nod over those without, but when it comes down to actual practice their knowledge about motor vehicles is what accounts* (PP4, p. 9).

In a similar manner to the scientific component, the vocational component comprises specific vocational knowledge and general vocational knowledge. The general vocational knowledge comprises knowledge and skills which are nearly shared by all forensic practitioners such as the general principles of forensic science: **Locard's Exchange Principle**, **The Principle of Uniqueness**, and **The Principle of Individualisation** (Horswell, 2004) and the general aspects of crime scene processing: crime scene entrance and exit, photography, and exhibit collection (White, 2004).

In addition to general vocational knowledge, each specific division/area of forensic science possesses specific knowledge explicit to that division/area. Examples of specific forensic areas and the specific vocational knowledge possessed by these areas are presented in Table-5k.

Specific Forensic Areas	Examples of Specific Vocational Knowledge
Firearms and Ballistics	*We look at the dynamics of firearm discharge and the technical side of firearms... how the trigger works; how that firearm functions; how does a cartridge work are basic technical firearms identification processes... we try to identify the presence of individual characteristics that are unique to that particular firearm or tool... once we identify those features and move into comparing that with the exhibit, we then do what we call a conservative identification of individual characteristics, looking at patterns and those patterns can assume a certain a number, a certain width, a certain height and amongst that mass of individual characteristics you can then exclude, or identify a firearm* (PP1, p. 3).
Motor Vehicle Examination	*We look at stolen and suspected motor vehicles where we investigate attempts to re-identify and re-register the vehicle in a new identity... a lot of times we have to interpret things such as whether the panel, where the chassis number is located, is original to the car or whether you can see non-packed welding holding the panel in... many cases requires methodology in serial numbers where we perform physical restoration... we might restore a curve here, bit of a line there and a funny zigzag over here and we can say "well this a 12 Land Cruiser chassis number... we look at accidents, hit and runs, and crimes which involve motor vehicles in an attempt to identify the possible vehicle... we investigate arson cases which involves vehicles to see whether or not the fire was planned...* (PP4, p12).
Blood Pattern Analysis	*In this particular scene the way, the distribution of blood was fairly localised to one area, so by examining the particular patterns of blood , I was fairly confidently able to conclude that the person was at a particularly well defined area because most of the blood was contained in between a wall and a coach, and there was no wider than a metre, most of the blood stain was very low to the ground and there were some few directional stereotype stains and it was fairly clear to me that the person was low to the ground whilst receiving numerous blows, and that the blood stains actually indicated that.... I was able to see that a lot of force had been used in order to account for the way the blood had been distributed and was able to account well that person has contacted various objects within the room by looking at the blood pattern for example* (PP3, p16).

Table-5k

Exemplar 3

Forensics is science that pertains to law (Camenson, 2001). Therefore, the emphasis by a number of participants (e.g. EP4, PP3, and PP5) on the necessity to acquire legal knowledge emerges from a substantial ground. Legal knowledge is not supposed to be in depth to either override the scientific knowledge of forensic practitioners, or shape these practitioners with a legal identity. This is because forensic practitioners are first and foremost scientists (AP3 and AP4) whose role is to present their evidence, opinions, and analyses from a scientific perspective and not from a legal one.

> *What you're really interested in is their analysis of science not their analysis of law… they're really not here to give evidence about law, they're here to give evidence about their scientific expertise …* (AP3, p.2).

Hence, legal knowledge needs only to be required to a level where practitioners: a) appreciate the judicial system to which they report and witness, b) appreciate the value of the evidence presented to a court, c) possess a general awareness of the governing legislation under which they operate, and d) realize where they fit into the whole scenario.

Exemplar 4

In forensic science, there exist a number of forensic capabilities, the most essential of which are critical thinking and communication skills. It is vital for any individual seeking work within forensic science to possess these capabilities. To start with, critical thinking is one of the most important generic skills- if not the most important of all- in many professions (Assister, 1995; Beyer, 1987; Elander et. Al., 2006). Therefore, it is very obvious that such a skill is essential in a field of practice such as forensic science, where practice settings are built on solving mysterious incidents, puzzling crimes, and conflicts. Critical thinking is required in almost all forensic tasks and activities. Forensic science practitioners need to be critical thinkers when examining exhibits, applying tests, analysing exhibits, relating/linking evidence to a suspect, and rebuilding the whole case scenario. They need to be critical thinkers in looking 'outside the box' and in approaching 'problems and complex issues' (EP3, p. 7). In other words, forensic practitioners need to be critical in problem solving in a field based on solving problems, conflicts, and murders.

Communication skills, including both written and verbal skills, constitute one of the major building blocks of forensic science practice (Davey, 2008; White, 2004). Regardless of how skilled, knowledgeable, and educated forensic scientists may be, the value of any forensic evidence and findings might be lost if not properly communicated in a court of law (McCormack, 2005). The importance of communication skills were emphasised by all interviewees in all three groups of participants (IC2).

> *If you've got the best scientists with very high academic background and they are not competent enough to communicate their evidence to a jury, then all the value of their evidence is probably gone* (EP2, p. 10).

<u>Summary</u>

The research identified a general set of four knowledge exemplars which may be used to identify features of forensic science knowledge and create an interconnecting framework of knowledge and competencies within the field. The first exemplar showed the scientific nature of forensic science knowledge, whilst the second pointed to the vocational nature of such knowledge. The third exemplar stressed the legal component which is embedded within forensic science knowledge. The fourth exemplar comprised the forensic capabilities essential to everyday forensic practice.

5.4.3- Education which responds to the nature of forensic science knowledge and emphasises knowledge exemplars

In this subsection, the research first examined the various forensic social groups and their respective perceptions of forensic science knowledge and education. The research then identified learning settings which emphasise the identified forensic knowledge themes and exemplars. Finally, complexity issues arising from such an emphasis are addressed.

Forensic Social Groups

Forensic science includes a variety of professions that are incorporated within its applications or associated with its services (IC1). For instance, chemists (EP1, EP3, and PP5), biologists (EP2, EP4, PP3, and PP6), psychologists (AP1), sworn police officers (AP2, PP1, PP2, and PP4), and barristers (AP3 and AP4) represents few of the many personnel who are either stakeholders or possess a bona fide interest in forensic science. This complements with a commonly accepted understanding that the landscape of forensic science is very broad as it draws on a variety of disciplines and professions (Bell, 2004; Inman and Rudin, 2001).

Each particular group of stakeholders of forensic science possesses particular expectations about forensic science knowledge. These expectations are mainly concerned with the knowledge base and disciplines which need to be emphasised in a course of study or training program. Those expectations in certain instances complement and in other instances contradict each other.

Differences in interests, perceptions, and expectations existed between different groups of participants. For example, the majority of the first and second group participants argued for the necessity of the incorporation of a legal component within forensic science knowledge. However, the third group participants, specifically AP3 and AP4 (barristers), argued against such incorporation (IC2). Such conflict in perceptions and expectations did not only occur amongst the different participating groups, but also existed within the perceptions of same group participants, particularly the second group (forensic science practitioners). Amongst the second group participants, differences existed between field practitioners and laboratory practitioners in terms of their educational backgrounds, perceptions, and positions towards a number of knowledge conceptions.

Differentiation starts from the education backgrounds of the two subgroups, and then extends to cover each subgroup's perception of a number of issues, the most fundamental of which is the nature of forensic science knowledge. A summary table (table-5L) emphasises such differentiation.

	Field Practitioners	**Laboratory Practitioners**	**Portrayed Category**
Background	Generally lack tertiary science education	Generally possess tertiary science education	IC1
Perception of the nature of forensic knowledge	Not a science or only crude science	Science exists in the core of every task	IC2
	Experiential in nature	Theoretical and experiential	IC2
Perception of Tertiary Education	Unnecessary in their practice	Vital for forensic science practice	IC5

Table- 5L

These different perceptions and views held by various social groups reflect Bernstein's notion of power and control, where a particular social group possesses its preferred ways in representing and dealing with the knowledge relevant to its field (2000). This also suggests Pinar's notion of the curriculum as being a 'complex conversation' between various stakeholders (2004). This discussion will be further explored and developed in Chapters 8 and 9 (the discussion chapters) after analysing the perceptions and expectations of the various forensic social groups in relation to forensic science practice (Chapter 6) and identity (Chapter 7).

<u>Learning Settings which Emphasise the Identified Forensic Knowledge Themes and Exemplars</u>

Following from the four identified themes and their corresponding exemplars, forensic science education needs to emphasise:

- Formal learning settings which convey the specialised scientific nature of forensic science knowledge (Theme 1). Such nature, according to the majority of the participants, requires the incorporation of a heavy and specialised science discipline (e.g. chemistry or biology). This specialised science discipline has to form the most dominant component within the syllabus of a course of study, even if such dominance occurs at the expense of the forensic science component. This is because deficiencies in science education may not be recovered at a later stage through workplace learning (EP1, EP2, and EP3). On the other hand, the forensic science component may be 'compromised' during tertiary education, because senior practitioners 'can always fill gaps in the forensic science education' of new trainees, 'but they can't fill gaps in their science education' (EP3, p. 4). Engber, in this respect, argued that it is always easier to teach a chemist or a biologist how to identify, collect, preserve, and analyse forensic evidence, than it is to teach a forensic investigator the fundamental theories and principles of chemistry or biology (2005).

- Informal learning settings which explore the vocational nature of forensic science knowledge (Theme 2). Forensic science incorporates complex problems that may be hard to solve and questions that may be difficult to answer, unlike the classroom environment where there is an answer for every question and a solution for every problem (Cavallo, 2006). These settings need to emphasise those forensic areas and topics which can only be acquired and learnt within a practice-based context. Such a context may not be replicated into a university or classroom setting. One of these areas is blood pattern analysis (EP2, PP2, PP3 and PP6). Blood pattern analysis requires students to be 'exposed to real blood' and to 'how it might be distributed' (PP3, p.7). This may only be achieved within a real crime scene setting through attending 'hundreds of crime scenes' (PP2, p. 7).

- Legal contexts (Theme 3) through which science is examined and explored.

- A set of teaching and learning strategies which emphasises essential forensic capabilities (Theme 4). The emphasis and promotion of such skills may not be restricted to one teaching approach or pedagogy, but to a number of strategies both academic (e.g. LBL and PBL), and non-academic (e.g. workplace learning) (Garside, 1996; Elander et al., 2006).

Educational Complexity in the Emphasis of the Identified Forensic Knowledge Themes and Exemplars

Emphasising the four identified forensic knowledge exemplars in the one course of study is complex for two main reasons:

- Stressing all of the science components (both specialised and general), vocational forensic components (both specialised and general), legal component, and essential forensic capabilities in the one curriculum is problematic. In this respect, participant EP1 anecdotally commented that should a higher education institute decide to set a course which emphasises all the disciplines required for or related to forensic science, then “it will be a thirty-year course” (p. 2). On the other hand, if a higher education institute decides to “squeeze” all these disciplines into a 3- or 4-years course, then such an institute will be doing things “at a really superficial level” and graduating students who are not specialists in any one discipline 0(EP1, p. 2).

- The nature of each of the four knowledge exemplars might require curricular approaches and pedagogies which are different from one another. For instance, exemplar 1, which is more related to theoretical knowledge, might require a more disciplinary approach, such as a multidisciplinary curriculum, where ‘students see the field from various angles … but at the end of the day use and specialise in one discipline’ (EP3, p. 3). Scientific theories might require more conventional teaching and learning strategies which are efficient to stress these theories such as LBL. On the other hand, Exemplar 2, which is more related to vocational capabilities, might require a more integrated curricular approach, which is capable of drawing on a number of disciplines to perform the one task. Exemplar 2 might also require an informal practice-based learning setting, which facilitates exposure to real crime scenes and practice settings.

Further discussions about approaching curricular and pedagogical complexity related to forensic science knowledge will be addressed in Chapter 9, after identifying potential complexities facing forensic science education in terms of the nature of forensic science practice (Chapter 6) and identity (Chapter 7).

<u>Summary</u>

In this subsection, the research identified various forensic social groups who held perceptions and expectations of forensic knowledge which complemented in certain instances and contradicted in others. The research also identified the learning settings which emphasise the identified forensic knowledge themes and exemplars and complexity issues arising from such an emphasis.

5.5- Chapter Summary

This chapter is the first of three chapters which present qualitative analysis of interview data exploring the nature of the determining factors of forensic science education: forensic science knowledge, practice, and identity. This chapter approached the nature of forensic science education from a forensic science knowledge perspective. The findings of the chapter were organised and presented in four sections. The first section summarised the preceding chapter (Chapter 4) and introduced this chapter in terms of its aim, structure, and relation with the following chapters (Chapters 6 and 7).

The second section presented categories of description of forensic science knowledge identified by this study. Five qualitative conceptual knowledge categories were identified with segments from interviews which show the breadth of the meaning of each category. In capturing the meaning of each of the five categories, particular attention was given to show the perceptions, positions, and/or expectations of each of the three participating groups of interviewees from each knowledge category. Therefore, the perceptions of each of the participating groups from each category of description were addressed in an independent subsection.

The third section analysed the perceptions across the three groups of participants in each of the five identified categories. This inter-categorical analysis allowed the observation of each categorical knowledge conception not only from the perspective of each individual participating group, but also as the summation of the perceptions and experiences of the three groups of participants in relation to forensic science knowledge.

Inter-categorical analysis was conducted following a table which summarised the overall position and viewpoint of each of the three participating groups from the conceptual category in analysis. These tables showed the frequency of occurrence of the conception amongst the participants of the three groups. The frequency of occurrence is reported in the tables to show the degree of consensus each conception enjoyed. It is not a measure of statistical significance.

The fourth section identified four cross-category themes which emerged as a result of pedagogical discourse amongst the identified inter-categorical knowledge attributes in the third section. Each identified theme was then exemplified into a practical component. Finally, forensic science education was examined in terms of the different power groups impacting forensic science knowledge, the learning settings required to respond to the identified forensic themes and exemplars, and complexity issues which arises from such a response.

As a whole, this chapter presented participants' conceptions of forensic science knowledge and an analysis of these conceptions. The following chapter provides a presentation and analysis of participants' conception of forensic science practice.

Chapter 6: Conceptions of Forensic Science Practice

6.1- Introduction

The previous chapter (Chapter 5) provided a presentation and analysis of research participants' conceptions of forensic science knowledge. This chapter presents participants' conceptions of forensic science practice and an analysis of such conceptions. Interviewees' perceptions and conceptions of forensic science identity are addressed in Chapter 7.

Data analysis in this chapter is organised in three sections (section-6.2, section-6.3, and section-6.4). Section-6.2 presents topic coding, where four conceptual categories of description relating to forensic science practice were identified. These conceptual categories were revealed by the perceptions of the research participants. The stance of each of the three groups of participants (forensic science educators, forensic science practitioners, and members of associated professions) from each of the identified categories of description is individually presented.

Section-6.3 presents an inter-categorical analysis of each of the four categories of description. This inter-categorical analysis took the form of a conversation between the perceptions of each group of participants in relation to each practice category. Such conversation allowed the examination of the overall stance from each category and the identification of inter-categorical practice attributes.

Section-6.4 presents a cross-categorical synthesis of the identified inter-categorical conceptual attributes (section-6.3). Pedagogical discourse was conducted between these attributes to generate forensic practice themes. Four forensic science practice themes were identified. These themes were then explained by the writing of four practice exemplars. Finally, implications for forensic science education from a practice perspective were generated. An organisational chart representing the various stages of data analysis process in this chapter is presented in Figure-6a.

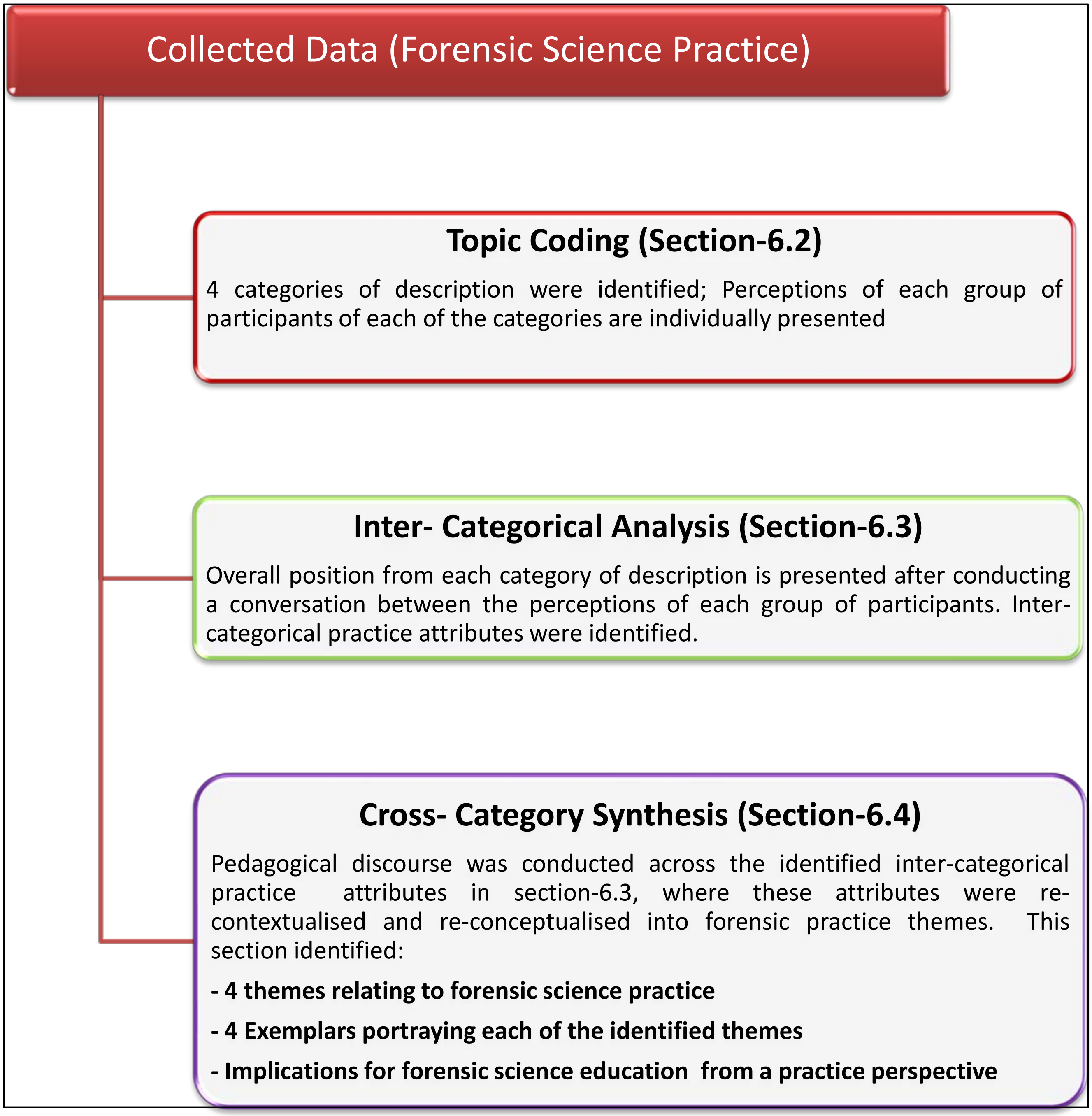

Collected Data (Forensic Science Practice)
Topic Coding (Section-6.2)
4 categories of description were identified; Perceptions of each group of participants of each of the categories are individually presented
Inter- Categorical Analysis (Section-6.3)
Overall position from each category of description is presented after conducting a conversation between the perceptions of each group of participants. Inter-categorical practice attributes were identified.
Cross- Category Synthesis (Section-6.4)
Pedagogical discourse was conducted across the identified inter-categorical practice attributes in section-6.3, where these attributes were re-contextualised and re-conceptualised into forensic practice themes. This section identified:
- 4 themes relating to forensic science practice
- 4 Exemplars portraying each of the identified themes
- Implications for forensic science education from a practice perspective

Figure-6a

6.2- Topic Coding: Categories of Conceptual Practice Attributes

This section addresses four categories of description representing the major qualitative conceptual practice attributes of forensic science, as identified by the responses of the participating interviewees. For each category of description, the responses and perceptions of each group of participants relating to that category were individually presented. Inter-categorical analysis across the perceptions of the three groups of participants in relation to conceptions in each of the four categories of description is conducted in the following section. The identified four categories of description relating to forensic science practice are:

- Category 1: The place of the crime scene in forensic science practice
- Category 2: The notions of forensic science practice
- Category 3: Segmentation within forensic science practice
- Category 4: Essential forensic practice competencies

6.2.1- Category 1: The Place of the Crime Scene in Forensic Practice

Forensics often starts following a crime. Therefore, the crime scene is the primary workplace of forensic practitioners, from which all examinations, testing, and analyses emerge. In this section, the research explored the necessity of the proper handling, processing, and investigating of the crime scene for the efficiency and authenticity of further examination, testing, and analyses.

6.2.1.1- The Place of the Crime Scene in Forensic Practice as Perceived by the First Group Participants

Participating educators asserted that the proper training of crime scene investigators is essential and is a priority, because any consequent laboratory examination and analysis is useless should the exhibits be improperly collected from the crime scene.

> *The proper training of crime scene investigators is extremely important for forensic science practice because all consequent steps and analysis depend on the first step… the exhibit may not be properly collected, the collected quantities may be insufficient, the collected sample may be contaminated, a primary exhibit*

> *may be overlooked … if anything of this happens, then that's it: all consequent steps are useless and a waste of time, energy, and labour… the proper processing of the crime scene is a must for the practice* (EP2, p6).

Moreover, crime scene investigators, who are not properly trained, may overlook exhibits which may be vital for crime investigation and the identification of an offender. They may negatively impact the system with delays, waste of effort, and money.

> *There is huge cost in terms of money and labour associated with the downstream cost of mid-samples and if they [forensic practitioners] do not collect it properly they do not get the results that may otherwise would had been obtained, and there has been a lot of delays and wasted time without getting results.... the bottom line is that we want them to be able to target the right type of sample, and collect sufficient amounts… giving the best chance again to get results* (EP4, p.5).

6.2.1.2- The Place of the Crime Scene in Forensic Practice as Perceived by the Second Group Participants

There was consensus amongst the participating forensic science practitioners about the importance of the proper processing and handling of the crime scene, because any further analysis at the laboratory is useless if the collected exhibit is contaminated or mishandled:

> *The scene is measured up, everything detailed around the body in immediate rooms and then we need to liaise with the investigators to see, there was an ambulance that attended; what did the ambulance move? What did they see when they first came in? So that we can then base an understanding of what the scene was like in a pristine condition before it had been contaminated by paramedics… the most important thing would be the proper handling and collection of the evidence in terms of not only the collection part, too much that we haven't contaminated it, and we've got the best possible samples that we can get, the handling and the movement of the item, that's now become integral, because any subsequent examination relies purely on how we've actually done the collection* (PP2, p16).

6.2.1.3- The Place of the Crime Scene in Forensic Practice as Perceived by the Third Group Participants

Participating members of associated professions asserted the importance of the proper handling of the crime scene. Participating barristers emphasised that any gap in crime scene processing and investigation will be challenged at a later stage during a trial and may impinge on the authenticity of presented evidence and associated forensic analysis

> *Crime scene forms the window through which defence barristers attempt to attack prosecution, police investigation, and forensic analysis… the way the crime scene is handled and processed, the possibility of contamination and the extent of exhibits' contamination are fundamental issues by which any presented evidence to a court may be challenged as illegitimate (*AP3, p.7).

> *Doubt can be easily cast about elements of the charge once the procedures of crime scene handling, processing, and investigation have been challenged as improper or incomplete… it will then be hard to prove any consequent forensic analysis and investigation as genuine* (AP4, p. 5).

6.2.1.4- Summary of the First Category of Description

There was consensus amongst all participating groups that the most fundamental and vital phase in forensic science practice is crime scene investigation. Should this primary and fundamental phase not be properly and proficiently conducted, all consequent and associated steps become of depleted value, if any. Moreover, the improper collection of samples- whether in quality or in quantity- ultimately results in the waste of money, time, and energy and exacerbates the issue of work backlog.

From a legal perspective, the improper investigation of the crime scene weakens the support for a charge and cast doubt in the minds of the jury and judge about the authenticity of presented evidence.

6.2.2- Category 2: The Notions of Forensic Science Practice

In this category the research identified the features which characterise forensic science practice. Features of forensic science practice were identified from: a) the perceptions of the participating forensic science educators, b) the experiences of the participating forensic science practitioners, and c) the informed opinions of members of associated professions.

6.2.2.1- The Notions of Forensic Practice as Perceived by the First Group Participants

The participating forensic science educators emphasised the features of forensic science practice from their perspective. Their perceptions about the characteristics of forensic science practice did not solely emerge from their positions as being educators, but also came out from the fact that the majority of them (EP1, EP2, and EP4) had practised forensic science as forensic chemists or forensic biologists for a number of years prior to becoming educators in the field.

Bureaucracy of Practice

Forensic science educators argued that the settings of forensic science practice may be more bureaucratic than other professions. This is because forensic science practitioners are expected not to commit mistakes. They are required not to undertake shortcuts in the conduct of their practice which may compromise the quality of the work regardless of the pressure exerted and the timelines set to finish a particular task.

> *In terms of mistakes everybody commits mistakes, but forensic scientists aren't allowed to make any and as a result their systems can be a little bureaucratic, and practitioners need to be strong enough not to take short-cuts when they're under pressure…* (EP2, p12).

Unexpected Settings of Forensic Practice

The settings of forensic practice are characterised by being unexpected. Practitioners cannot foresee or anticipate the settings of a crime scene until they have explored it.

> *It is hard and difficult for practitioners to predict or expect what methods or techniques they're going to use at a crime scene… they might be photographing a crime scene in a badly lit corridor at 2 o'clock in the morning or at a deserted bush under rain and thunder* (EP2, p12).

> *The crime scene settings may not be anticipated because although there are always common things between predators, you can never assume the way predators behave before, during, and after committing their crimes and you can never assume the way victims react to such behaviour…* (EP1, p10).

<u>Manual Demands of Practice</u>

Forensic science practice, despite all the technological advancement and computerised machinery, still requires the manual examination and testing of evidence and exhibits.

> *Technology is important in our field, but in many instances manual examination and assessment of evidence or victim are required and will always be...* (EP2, p9).

<u>Summary</u>

The first group participants argued that forensic science practice may be more bureaucratic than other practices because maintaining the quality of work is critically important and may not be compromised for whatever reason. They also stressed that the settings of a crime scene may not be expected or anticipated before hand, because each individual predator or offender behaves in a different manner in different situations.

6.2.2.2- The Notions of Forensic Practice as Perceived by the Second Group Participants

The participating forensic science practitioners expressed their perceptions of the features of their practice as they experience it in everyday work.

<u>The Specialised Nature of Practice</u>

Forensic science practice is specialised. The nature and circumstances of a crime may attract various specialisations and fields of knowledge. However, each forensic practitioner is specialised in performing a specific task. For example, fingerprinting is conducted by a fingerprint expert, firearms are examined by a firearms and ballistics expert, and vehicle examination is conducted by vehicle examination expert.

> *I work in the vehicle examination unit, I look at stolen motor vehicles... that's predominantly my work... we look at anything that has a serial number except for firearms which go down to the firearm and the tool mark guys* (PP4, p.13).

The Contribution of Various Professions into Field Practice

Although practice is specialised, access to crime scenes is not limited to detectives and crime scene investigators, who are often the first to arrive where they start observing, taking notes, photographing, etc. Crime scenes are also open to any personnel whose specialisations are demanded by the nature of the crime or the nature of exhibits such as forensic pathologists, forensic chemists, forensic biologists, firearms and ballistics officers, etc.

> *Monday straight after work, we've got a case that fire has occurred and the injured was a police officer and the man may not make it, so we went out to the scene and investigated where the fire started and how it started. So it was quite interesting with so many people there; there were many detectives and the arson squad and forensic chemists and arson chemists from other places. So it was interesting to see how we interact with other parts of the police forces…* (PP5, p18).

Different types of exhibits left over on a crime scene demand the presence of various practitioners to assess them; however, sometimes the one exhibit, which possesses different types of evidence, requires the inclusion of different specialisations. For example, a suspected firearm left at a crime scene may have blood on it. This firearm needs to be examined by both a firearm officer, and a forensic biologist.

> *There are cases where there is a possibility to get DNA from blood left on firearms or lift fingerprints left over. In this case we only assess the firearms in finding how the shooting happened… a forensic biologist will attend and do the swabbing for the DNA and a fingerprint expert would attend and lift fingerprints… so yes sometimes evidence coincides (*PP1, p15).

At the crime scene, the various personnel attending the scene need to collaborate, communicate, and exchange information and viewpoints:

> *We speak to the investigator and give the investigator our opinion of whether we believe the death is suspicious or not, the undertaker can remove the body, take it down to the coroner's room for the post-mortem to conduct it… so it's not just us; it's us amongst other people… so we exchange our opinions with any statements, information that they [detectives] would receive in conjunction with what the pathologist may perceive, so it's a joint picture* (PP2, p15).

<u>The Unexpected Settings of Forensic Practice</u>

Another feature of practice is the crime scene settings whose characteristics may not be presumed, anticipated, or expected beforehand.

> *Well I guess, you often never know what you'll be examining … even if you do know what it is, you don't know in what condition it will be... Every time you're examining exhibits you're presented with new challenges in terms of how you might go about sampling, determining what the best way might be to proceed with your examination and you need to be mindful of the fact that if your collection will alter the exhibits and if so, what further complications would that have down the track… so you really need to think about what you're doing very carefully before you do it. You need to take very good notes because continuity of exhibits is very important in this area of work* (PP3, p18).

<u>Summary</u>

The participating practitioners argued that forensic science practice is specialised. However, the crime scene scenario and crime settings may attract a variety of forensic personnel of different specialisations. Different personnel at the crime scene need to communicate, exchange information and opinions, in order to contribute to the case solution. The conditions at a crime scene are often hard to predict beforehand. Every time forensic practitioners go out to a crime scene, they are presented with new challenges.

6.2.2.3- The Notions of Forensic Practice as Perceived by the Third Group Participants

The participating members of associated professions held informed opinions about the features of forensic science practice as a result of their regular contact with forensic science practitioners at the crime scene and in the courts. In this respect, they asserted that forensic science practitioners do not operate in vacuum. Forensic science practice complements a variety of disciplines from a variety of professions.

> *In sexual offences, as an example, we deal with forensic scientists in terms of DNA analysis, semen analysis those sort of analyses in terms of what they may inform our psychological assessment… we rely on the forensic science skills there… sometimes you have a man in front of you who says: Oh I love my daughter very much, I could never thought of harassing her, and yet we've got the evidence there, the biological evidence that this father did sex with his daughter…*(AP1, p3).

> *My work is very closely related to forensic science... my expectation would be that they [forensic practitioners] will at least be able to work in collaboration with the people that are seeking their services, provide feedback and have good communication. I think the main thing; you need to have proper communication between the investigator [detective] and the scientists* (AP2, p7).

Hence, the nature of forensic science practice requires the collaboration and communication of various personnel from various backgrounds and speciality areas.

6.2.2.4- Summary of the Second Category of Description

The first group participants argued that forensic science practice may be more bureaucratic than other practices because the quality of work is very critical and may not be compromised for whatever reason. They also stressed that the settings of a crime scene may not be expected or anticipated before hand, because each individual offender behaves in a different manner in different situations.

The second group participants asserted that forensic science practice is of a specialised nature, where each forensic practitioner is required to perform a specific task.

However, the nature of exhibits left at crime scene might demand the presence of various practitioners from various speciality areas to assess such exhibits. Hence, different personnel attending the crime scene need to communicate and exchange information and opinions in order to contribute to the crime solution. Participating practitioners argued that the characteristics of crime settings are often hard to predict. Every time forensic practitioners go out to a crime scene, they are presented with new challenges.

The third group participants asserted that forensic science practice is not conducted in a vacuum. Many practitioners of various professions such as psychologists and detectives rely on the identified forensic evidence to inform their assessments. This complementary relation demands proper collaboration and communication between forensic science practitioners and members of associated professions in order to succeed in the conclusion of the investigation and the prosecution of offenders.

6.2.3- Category 3: Segmentation within Forensic Science Practice

In this category the research identified the segmentation which exists across forensic science practice as argued by each group of participants.

6.2.3.1- Segmentation amongst Practice as Perceived by the First Group Participants

The participating educators, when asked questions which prompted the nature of forensic science practice, stressed the differences which exist between forensic field practitioners and laboratory practitioners. Moreover they asserted that differences not only exist between the two groups of practitioners, but also amongst field practitioners themselves.

<u>Differentiation between Laboratory and Field Practice</u>

Differentiation exists between laboratory practice and field practice. This differentiation starts with the prerequisites for employment in each category of practice, and extends to cover differences in training, practice standards, assessment, and the amount of science done in the field versus the laboratory.

> *Currently there are differences between the nature of forensic science practice between fieldwork and laboratory work which starts with the prerequisites for employment, standards applied, and many other things, most importantly the amount of science used… the amount of science used in the field is scarce when compared to the lab… but we hope in the future that we will have science in the field as much as we have in the lab* (EP3, p12).

In addition, field practitioners are often less scientifically educated personnel when compared to laboratory practitioners.

> *Field practitioners are often police officers with secondary school education, whilst lab practitioners are civilians with higher education and sometimes postgraduate qualifications* (EP4, p13).

Differentiation amongst Field Practices

Differentiation also exists amongst the various forensic field specialisations where each speciality area has its independent 'training and accreditation process', and 'separate journals and publications' (EP4, p13).

Summary

The first group participants asserted that segmentation exists between forensic field practice and laboratory practice. Differentiation starts with the prerequisites for each category of employment, and extends to cover differences in training, practice standards, assessment, to the amount of science done in the field versus that done in the laboratory. Field practitioners are usually less scientifically educated than the laboratory practitioners. Participating educators also stressed that differentiation also exists amongst the different field specialisations in terms of their training, accreditation process, and publications.

6.2.3.2- Segmentation within Practice as Perceived by the Second Group Participants

Differentiation was emphasised by the participating practitioners in regard to two main issues:

a) The more scientific laboratory practice versus the more technical, yet less scientific, field practice and
b) The contribution of laboratory practitioners into field work in certain instances versus the restriction of field practitioners to field work.

Scientific Laboratory Practice versus Vocational Field Practice

The participating practitioners asserted that field practice is more technical and less scientific in nature when compared to the more scientific nature of laboratory practice. This is evident from the direct quote of field practitioner PP2 who is a crime scene investigator:

> *We collect items that we deem valuable, anything like of forensic nature for subsequent examination. Some of the examination if its physical we do ourselves, if its scientific then we hand it to the specialist: the scientific officer to then perform laboratory-based tests… we are more the eyes and the front line of the forensic science laboratory here, we bring the work in and the testing and analysis are then done by the forensic scientists* (PP2, p16).

Restricted Access of Field Practitioners versus Open Access of Laboratory Practitioners

Currently field practitioners - with the exception of a few jurisdictions which employ science graduates in these positions- can only practice in the field. On the other hand, laboratory practitioners, in addition to their daily practice in the laboratory, do sometimes attend crime scenes and assist in their processing especially when it comes to very serious crimes or crimes of complicated nature.

> *Last Thursday I was in the lab doing my work as per usual and I was asked to attend the crime scene, a homicide scene, so I guess that's part of the job here where majority of the work is lab-based but I guess at any given time you could be called out, outside the lab to go to the crime scene.* (PP3, p16).

> *I'd do additional crime scene work, so that means on occasions I'll go out from the lab to the crime scene whether that'd be for luminal testing, or acid phosphatase testing, or blood pattern analysis…* (PP6, p14).

<u>Summary</u>

The second group participants asserted that there is differentiation in forensic practice between field work and laboratory work. Participating practitioners emphasised two aspects of differentiation: a) the more scientific laboratory practice versus the more technical field practice and b) the open access for laboratory practitioners into field work versus the restricted access of field practitioners into laboratory work.

6.2.3.3- Segmentation within Practice as Perceived by the Third Group Participants

Participating members of associated professions approached differentiation within forensic science practice mainly through the policing nature of crime scene examination versus the science nature of laboratory practice.

> *I see police doing more of the crime scene investigation whereas scientists do more of the laboratory analysis…* (AP1, p.5).

> *In their testimonies, sworn police members often testify in matters dealing with crime scene examination, whilst scientists often testify in the scientific analysis of evidence…* (AP4, p.4).

The third group participants emphasised that- through their experiences on the crime scene and at courts- they often observe forensic field roles being held by sworn police officers, in contrary to forensic laboratory roles which are occupied by scientists.

6.2.3.4- Summary of the Third Category of Description

The first group participants argued that segmentation between forensic field practice and laboratory practice is reflected in differences in the prerequisites for employment, training requirements, practice standards, assessment practices, the level of science education, and the amount of science done in the field versus that done in the laboratory.

The second group participants asserted that segmentation between field work and laboratory work is mainly reflected through: a) the more scientific nature of laboratory practice versus the more technical nature of field practice and b) the contribution of laboratory practitioners into field work versus the inaccessibility of field practitioners into laboratory work.

The third group participants emphasised that differentiation within forensic science practice mainly exists through the policing nature of forensic field roles (e.g. crime scene examination) versus the science nature of laboratory roles.

6.2.4- Category 4: Essential Forensic Practice Competencies

In this section, the research identified the competencies essential for the conduct of forensic practice. Essential competencies for forensic science had already been emphasised from a knowledge perspective in chapter 5. In this section, the research stressed these competencies but this time from a practice perspective as emphasised by the interviewees.

6.2.4.1- Essential Forensic Practice Competencies Emphasised by the First Group Participants

There was consensus amongst the participating educators that forensic science practitioners need to be critical thinkers. Forensic practitioners need to be critical in mainly every activity they conduct. They need to be critical in proposing a hypothesis, testing it and verifying it before coming to any conclusions. In addition, the first group participants emphasised the importance of communication skills: written, verbal, and body language to forensic practice.

Practical Competencies that practitioners should have are critical thinking and an analytical mind where they need not to jump into conclusions, instead they need to bring up a hypothesis, test this hypothesis and verify it. Practitioners have to be critical thinkers in every activity they conduct... They need to have good communication skills in order to communicate their results to the court in a balanced, unbiased, and impartial way... not just the words they use, their body language, the way that they respond to questions, the way they respond when possibly those questions need a little bit more critique or talent and that's when the body language definitely comes in (EP1, p13).

6.2.4.2- Essential Forensic Practice Competencies Emphasised by the Second Group Participants

Participating practitioners emphasised critical thinking and communication skills as essential capabilities in the conduct of their practice.

Competencies essential in our work is to be able to critically think and link things to together in order to build up the crime scenario... (PP2, p11).

You need to be able to properly and confidently communicate your results and the scientific premises underpinning these results to the court… (PP3, p11).

6.2.4.3- Essential Forensic Practice Competencies Emphasised by the Third Group Participants

The participating members of associated professions asserted that forensic practitioners need to be critical thinkers. They also need to be proficient communicators and specifically proficient in communicating the scientific premise upon which their analyses/opinions is based. This is evident from the following quotes:

A great part of a forensic scientist's work in a prosecution case is really how they present themselves in court (AP2, p7).

> *Well you expect them to be critical in their work and thinking... they need to have a high level of expertise and integrity and not be influenced by the side which called them to give evidence... I expect them to be on top of the details of the case they're giving evidence about and where relevant I expect them to be familiar with the latest research here and overseas* (AP3, p7).

6.2.4.3- Summary of the Fourth Category of Description

All the three participating groups asserted the importance of critical thinking and communication skills as vital capabilities to forensic science practice. Each of the participating groups approached these competencies from a perspective relevant to their backgrounds and experiences.

The first group participants emphasised that forensic practitioners need to be critical thinkers in not jumping to conclusions and adopting assumptions, but in testing any hypothesis and verifying it before drawing conclusions. Practitioners need to communicate their results in a rational and unbiased manner.

The second group participants approached critical thinking more from the perspective of linking evidence, events, and circumstances to one another in order to build up the scenario of the committed crime. They emphasised communication skills as essential to the practice.

The third group participants asserted that forensic practitioners need to be critical thinkers. They also need to be accurate, straightforward, and confident in presenting their results, regardless of how hostile the scrutiny and attack by barristers might be. They need to be critical in communicating the scientific premises upon which their results are based.

6.3- Inter-categorical Analysis

Subsequent to 'categorical coding' where four conceptual practice categories were identified, inter-categorical analysis was implemented as a conversation across the perceptions of the three groups of participants in each of identified categories. This strategy allowed each practice category to be observed not only from the perspective of each individual participating group, but also as the summation of the perceptions and experiences of the three groups of participants. It also allowed the generation of inter-categorical practice attributes.

6.3.1- Inter-categorical Analysis across the First Practice Category of Description

There was consensus amongst all the three groups of participants on the importance of the proper and scientific processing of the crime scene. The efficiency and authenticity of any consequent laboratory work is directly proportional to the proper and proficient processing of the crime scene. A summary of the opinion of each of the participating groups is detailed in Table-6a.

	Perceptions of the relation between crime scene and forensic practice
Educators	If the exhibit is not properly collected, the collected quantities are insufficient, the collected samples are contaminated, and/or a primary exhibit is overlooked, then all consequent steps are useless and a waste of time, energy, finance and labour.
Practitioners	The proper handling and collection of the evidence is essential for any subsequent examination, testing, and analysis.
Members of Associated Professions	The proper handling of the crime scene is very important and vital because any identified gap in crime scene processing and investigation will be challenged later on during the trial.

Table-6a

As a summary any consequent laboratory examination and analysis is useless and a waste of human and financial resources should the exhibits be improperly collected or overlooked from the crime scene. Any identified gap in crime scene processing and investigation will affect the authenticity of the presented evidence and will cast doubt on elements of the charge.

6.3.2- Inter-categorical Analysis across the Second Practice Category of Description

All three participating groups held opinions and perceptions about what characterises forensic science as a profession and field of practice. A summary of the perceptions of each of the participating groups is detailed in Table-6b.

	Perceptions about the features of forensic science practice
Educators	▪ The settings of forensic science practice seem to be more bureaucratic than other professions. ▪ The settings of forensic practice are characterised by being unexpected. ▪ Forensic science practice, despite all the technological advances, still requires the manual examination and testing of evidence and exhibits.
Practitioners	▪ Forensic science practice is specialised. Each forensic practitioner is specialised in performing a specific task. ▪ The nature and circumstances of a crime in many instances require the cooperation and collaboration between various specialisations and fields of knowledge for the assessment of the one exhibit or different types of exhibits. ▪ The setting of a crime scene cannot be anticipated.
Members of Associated Professions	▪ Forensic science practitioners do not operate in a vacuum. Forensic science practice draws on a variety of disciplines from a variety of professions. This requires proper collaboration and communication amongst the different personnel attending the crime scene or involved in the crime investigation.

Table-6b

Amongst the various perceptions expressed by the various participating groups, there are perceptions which were emphasised by more than one participating group. The following table (Table-6c) presents those shared perceptions.

Participating groups sharing common perceptions	**Common Perceptions about the features of forensic science practice**
Educators & Practitioners	The nature of crime scene settings cannot be anticipated or expected.
Practitioners & Members of Associated Professions	Crime scenes may attract various specialisations and fields of knowledge for the assessment of crime scene exhibits. Such attraction demands that the various personnel attending the scene collaborate, communicate, and exchange information and opinions.

Table-6c

Despite the fact that there are acts and behaviours which are common amongst offenders when they're committing their crime or offence, there was consensus between participating educators and practitioners that the settings of a crime scene may not be expected or anticipated. Hence, every time practitioners are called to a crime scene they are faced with new challenges. This is because there is always a room for the unexpected and for surprises in the way the crime scene is set as a result of the unexpected actions of the offenders and/or reactions of the victims.

There was consensus between practitioners and members of associated professions that forensic science practitioners do not operate in isolation from one another and from professionals of other professions which might be invited to assess evidence on crime scenes or participate in the crime investigation. Therefore, it is a requirement to have a high level of cooperation and communication between the different personnel attending the crime scene in order to achieve a successful outcome.

6.3.3- Inter-categorical Analysis across the Third Practice Category of Description

There was consensus amongst the three groups of participants that there is differentiation within the forensic practice between laboratory practitioners and field practitioners. Each of the participating groups approached this issue from their distinct perspectives which complement with one another in the formation of a comprehensive understanding of the level and extent of the segmentation which takes place within forensic science practice. A summary of the opinions of each of the participating groups is detailed in the following table (Table-6d).

	Perceptions about the segmentation which exists amongst forensic science practice
Educators	▪ Differentiation starts with the prerequisites for each category of employment, and extends to cover differences in training, practice standards, assessment, and the amount of science done on field versus laboratory. ▪ Field practitioners are often the less scientifically educated personnel when compared to laboratory practitioners. ▪ Differentiation also exists amongst different jurisdictions in regard to field practitioners, where some jurisdictions still restrict crime scene investigation to sworn members of the police, whilst others encourage civilians with science degrees to apply for such positions.
Practitioners	▪ Differentiation exists in the more scientific laboratory practice versus the more technical, yet less scientific, field practice and ▪ Differentiation exists in the contribution of laboratory practitioners into field work in some instances versus the inaccessibility of field practitioners into laboratory work.
Members of Associated Professions	▪ Differentiation exists in the policing nature of field practice versus the science nature of laboratory practice.

Table-6d

Segmentation in forensic science practice starts with differences in the prerequisites for employment which are set for people who wish to join field or laboratory positions.

Prerequisites for field positions include the need for field practitioners to be sworn police members with experience relevant to the vacant field positions. Prerequisites for laboratory positions are often a tertiary science qualification which includes practical experience or research experience relevant to the vacant laboratory positions. Segmentation then occurs in the nature of training, practice standards, and assessment between laboratory and field practice. It then extends to affect the overall nature of practice, where field practice seems to be more technical and less scientific, in nature when compared to laboratory practice. Segmentation also exists in the open access of laboratory practitioners to field work versus the restricted access of field practitioners to laboratory work. In some instances, the more "scientifically educated" laboratory practitioners do attend crime scenes and contribute in their processing. On the other hand, the less "scientifically educated" field practitioners are often not permitted access to laboratory work.

6.3.4- Inter-categorical Analysis across the Fourth Practice Category of Description

All three participating groups emphasised the importance of critical thinking and communication skills as capabilities which are the most vital to forensic practice. It may seem that each of the participating groups approached these capabilities from a different perspective. Ultimately all perceptions complemented in emphasising the importance of both competencies as summarised by the following table (Table-6e).

	Critical Thinking	Communication Skills
Educators	In not jumping to conclusions and accepting assumptions, but in testing any hypothesis, verifying it, and then drawing conclusions.	To be competent in (a) communicating results to the court in a balanced, unbiased and impartial way and (b) responding to questions in a confidently, intelligently, and clearly manner.
Practitioners	In linking evidence, events, and circumstances to one another in order to build up the scenario of the committed crime.	To properly and confidently communicate results and the scientific premises underpinning these results in a clear, direct, and proper way in the witness box during the trial
Members of Associated Professions	In communicating the scientific premises upon which the analysis/opinion is based.	To communicate in a scientific, clear, simplified, and straightforward manner not influenced by the calling side (prosecution or defence); to give evidence and be able to deal with sometimes hostile cross-examination intended at undermining the weight of the expressed opinion.

Table-6e

The perspectives of each of the participating groups in emphasising critical thinking and communication skills ultimately complemented each other into drawing a comprehensive image of where, when, and how each of the competencies need to be used. Forensic practitioners are expected to be critical thinkers from the moment they commence working on a case. They need to be critical in how they examine things, what tests are to be used to obtain the best results, and the order of things to be done when the nature of an exhibit demands examination by different disciplines. They are expected to be scientifically critical in proposing, testing, and then verifying a hypothesis and the scientific premises upon which the hypothesis is built. By doing so, they can logically link certain possibilities about evidence, situations, and events whilst eliminating others. This contributes to building up a logical scenario about the committed crime and the sequence of events which took place.

Once examination, testing, and analysis of evidence and crime scene are conducted in a scientifically critical manner, communication of results can then be conducted with more confidence and detachment from both external and internal sources of pressure supported by a strong scientific premises and critically analysed process. Finally, practitioners need to communicate their results in an impartial, direct, clear, simplified and straightforward manner. When doing so, their testimony can stand whatever sorts of attacks and undermining attempts which may be initiated by either prosecution or defence, and which ultimately may be taken into account in a trial.

6.3.5- Summary of the Inter-Categorical Conceptual Attributes across the Four Categories of Description

The conceptual attributes arising from the inter-categorical analysis across the four categories of description are summarised in the following table (Table-6f).

	Summary of the Inter-categorical Practice Conceptual Attributes
1st Category of Description	The proper handling and processing of the crime scene are vital for any subsequent examination and testing and are essential to support elements of charge at a later stage.
2nd Category of Description	▪ The setting of a crime scene in many instances can provide a great deal of uncertainty and ambiguity, where forensic practitioners may face new challenges. ▪ Forensic science practice is specialised; however, the nature and circumstances of a crime scene often demand the contribution of various experts from various professions to assist in the scene's assessment.
3rd Category of Description	Forensic science practice is segmented between laboratory work and field work. There is also some sort of segmentation amongst field practices and specialisations.
4th Category of Description	Critical thinking and communication skills are vital competencies for the successful and proficient conduct of forensic practice.

Table-6f

6.4- Forensic Science Practice: A Cross- Categorical Synthesis

Following inter-categorical analysis, cross-category synthesis amongst the identified inter-categorical attributes took place in order to identify:

a) themes relating to the nature of forensic science practice,

b) a general set of exemplars reflecting forensic science practice, and

c) implications for forensic science education which respond to the practice of forensic science and emphasise the identified exemplars.

Cross-comparison synthesis was conducted in the form of a pedagogical discourse (Bernstein, 2000) between at least two inter-categorical practice attributes emerging from different categories of description. Such discourse allowed the identification of four practice themes subsequent to the recontexualising and reconceptualising of the inter-categorical practice attributes identified in section-6.3.

The four identified themes were practically elaborated by a set of four practice exemplar. Finally, the research reported implications for forensic science education which respond to the nature of forensic science practice and emphasise the practice exemplars.

For enhancing the readability of the thesis and ease of referring to the identified inter-categorical attributes in section 6.3, the research adopted the abbreviation of inter-categorical analysis of the first, second, third, and fourth categories of description to IC1, IC2, IC3, and IC4 respectively.

6.4.1- The Nature of Forensic Science Practice

Themes that meet specified criteria are reported in this chapter. The criteria for reporting the themes constituted three conditions:

1. The theme is not specific to any one perception of an individual participant or an individual group of participants.
2. The theme is generated following pedagogic discourse between at least two inter-categorical conceptual attributes emerging from different categories of description.
3. The theme is significant with respect to the major research question and supplementary research questions.

Theme 1: The Foundation of Forensic Science Practice

Comparison across the attributes of IC1 and IC2 showed that the crime scene investigation is not only an important starting phase of forensic practice, but also the foundation and core of such practice.

The crime scene requires proficient processing. This is because the incompetent processing of the crime scene (e.g. contamination of evidence, overlooking of exhibits, and/or improper collection of evidence in terms of quality and quantity) leads to deviation in the path of the investigation, incorrect analysis and in interpretation of evidence, and a potential ultimate miscarriage of justice (IC1). Crime scene practice requires the collaboration and cooperation of various specialisations to contribute to the observation, collection, and analysis of evidence (IC2). The crime scene is not only referred to at the commencement of the forensic investigation, but also at each stage of practice including the ultimate presentation of evidence at the court, as crime scene processing is always a window for the defence to attack and cast doubt into the elements of charge presented by the prosecution (IC1).

This is supported by literature, where many scholars have emphasised the central place of the crime scene to forensic science practice:

- The proper processing of a crime scene is the ‘linchpin’ of successful forensic investigations (Horswell, 2004).

- Laboratory analysis- regardless of how rigorous- is worthless if the evidence collected at the scene does not include samples of sufficient size, if control and reference samples are not taken, or if the packaging, labelling, and storage are inappropriate (NIJ, 1999; Horswell, 2004). Laboratory scientists cannot extract from the received samples any evidence more than what is collected (NIJ, 1999).

- Gaps in crime scene processing would eventually lead to weaknesses in the elements of charges presented to courts (Gaensslen, 2003).

Theme 2: The Complex Nature of Forensic Science Practice

The nature of forensic science practice is complex and challenging. This nature was identified following discourse between attributes of IC2 and IC4:

- The complex nature of the crime scene results in non-predictable forensic practice settings (IC2). In many instances, crime scene settings are likely to have unexpected features. Every crime scene is a new challenge to forensic practitioners, as they may possess settings and scenarios which may be familiar or unfamiliar to these practitioners.

- The nature of the crime scene in many instances demands the attendance and cooperation of personnel from different backgrounds and specialisations (IC2). Complexity arises when cooperation and communication are required between personnel of very different backgrounds. For instance, a crime involving shooting may require communication between:

    - a ballistics and firearms officer, who is an early school leaver that joined the police and then undertook training in the ballistics and firearms area, and

- a forensic pathologist, who is a medical practitioner that has undertaken and completed around 12 years of tertiary education.

- Forensic science practice requires forensic practitioners to communicate their scientific analyses and results to a non-scientific audience such as the judges, prosecutors, defence barristers, and members of the jury (IC4). Complexity arises when a forensic scientist is required to communicate highly sophisticated scientific language, terminologies, and expressions in a very simple language so that the ordinary person in a jury would understand it.

Theme 3: The Critical Nature of Forensic Science Practice

The complex nature of forensic science practice demands a critical response from forensic science practitioners. Hence, forensic practitioners are required to be critical in their: a) thinking (IC4), b) communication amongst their colleagues and personnel of various professions attending the crime scene (IC2), c) communication of results and opinions to the judicial system (IC4), and d) managing the unexpected challenges of a crime scene (IC2).

Theme4: The Segmented Nature of the Forensic Field

Pedagogical discourse between attributes of IC2 and IC3 revealed that forensic science practice is segmented between:

a) the highly professional scientific personnel (e.g. forensic pathologists and forensic entomologists) who are civilians and are often called to attend crime scenes and participate in its investigation and further forensic analyses at their laboratories,

b) the more scientific and less vocational laboratory practitioners, who are often civilians and who have access to both field and laboratory work, and

c) the more vocational and less scientific field practitioners, who are often sworn police members with restricted access to only field work.

Scholars argue that each profession or field of practice possesses a “community of practice” (Doak and Assimakopoulus, 2007; Duguid, 2005; Brown and Duguid, 2001). This community of practice sets the knowledge specific to the practice, facilitates learning interactions, and communicates experiences amongst the various members of the profession (Doak and Assimakopoulus, 2007). Unlike many professions, forensic science practice does not seem to possess a major community of practice. Segmentation which occurs between laboratory practitioners and highly professional scientific personnel on the one hand, and field practitioners on the other hand hinders the formation of a major community of practice.

Summary

The research identified four themes relating to the nature of forensic science practice. Theme1 emphasised that the crime scene is the foundation of forensic science practice. It is not only the primary workplace for forensic practitioners, but also the basis and core of this practice throughout all its stages. Theme 2 explored the complex and challenging nature of forensic science practice. Theme 3 elaborated the critical nature of forensic science practice which emerges in response to the complex nature of such practice. Finally, theme 4 stressed the segmented nature of this practice.

6.4.2- The General Set of Practice exemplars

This subsection presents four exemplars which elaborate the four themes related to forensic science practice. These exemplars are common amongst all forensic professions and speciality areas. The general set of practice exemplars may be used amongst:

- Forensic science educators to identify the practice components which need to be emphasised by a forensic course of study or a training program.

- Forensic practitioners to subscribe to an interconnecting framework of common elements amongst all the various practices incorporated within the forensic science field.

Each of the identified four exemplars illustrates one of the identified themes in subsection-6.4.1 by adding a practical component to it. Table-6g presents these exemplars and the themes from which they originated.

Identified Exemplar	Portrayed Theme
Exemplar 1: Forensic Sensibility of the Crime Scene	Theme 1
Exemplar 2: The Complexities of Forensic Science Practice	Theme 2
Exemplar 3: The Requirement for Critical Conduct in Forensic Science	Theme 3
Exemplar 4: The Segmented Forensic Science Community of Practice	Theme 4

Table-6g

Exemplar 1

Theme 1 identified crime scene practices to be the foundation and core practices of the forensic science work. This demands that all forensic science practitioners, despite whether they are field, laboratory, or highly professional practitioners (e.g. forensic pathologists), need to possess a forensic sensibility of the crime scene. Such sensibility is the result of an awareness of:

- The general practice of a crime scene: how to enter and exit a scene, whom to report to, how to identify, examine, and collect an evidence.

> *I was asked to attend a crime scene… so once notified, it's my responsibility to contact a crime scene member who is present at the scene and obtain some details about the scene and find exactly what my role is going to be… when I arrived, there was a police member there who was keeping a log of people's movement so who was coming in and out of the scene, so obviously when I first arrived I did let him know who I was, where I was from and make recording of all that information. And then the first thing I do is I request to speak to the police investigator in charge of the matter and also the crime scene examiner… in this particular case the crime scene examiner was still in the process of recording everything that was at the scene, so they were still taking video for each of various areas of the scene, and still taking photographs so in this particular case I*

had to wait until the crime scene examiner finished his work (PP3, p.12).

- The setting of a crime scene:
  - How a crime scene might look like: a shooting scene, a burglary, a murder;
  - The way thieves might break and enter into a property,
  - The way offenders might shoot,
  - The distance offenders might leave between them and the victim, and
  - The way offenders might leave or escape a crime scene.

> *You need to be experienced in what you would expect at various crime scenes: a shooting scene, a stepping scene, a rape scene, a brawl, how it looks if somebody breaks into a window...* (PP2, p. 3).

- The circumstances of a crime scene: the personnel who might be attending the scene (coroner, pathologists, detectives, arson chemists, etc).

> *In this particular case when we arrived a pathologist was there and… the pathologist can actually give a certificate of death and look at the body temperature and that sort of stuff to give his opinion of the likely circumstances of death. Then we start processing the scene photographing and recording it … we also had the biologist who did blood stain pattern analysis… There were other police from my division, there was a photographer, a video operator, and a crime scene examiner and there were also police detectives, there were a crew of a senior sergeant and six detectives and they had their job of interviewing suspects and witnesses* (PP2, p15).

Although forensic sensibility of crime scene practices is required for all forensic practitioners, the level and extent of such sensibility depend on the forensic practitioner's area of expertise and position. For example, crime scene awareness of PP2, who is a crime scene investigator, would be expected to be deeper than that of PP3, who is a forensic biologist. The main role of the first (PP2) is to investigate the crime scene in "*taking photos, video recording, collection of evidence, adopting enhancement techniques…*" (p. 15). Whereas, the main role of the second (PP3) is laboratory based, despite the instances when he is called to attend a crime scene:

> *The majority of my work is lab-based, but I guess at any given time I could be called out, outside the lab to go to court or to attend a crime scene* (PP3 P.11).

Exemplar 2

Theme 2 shows forensic science to be a complex field of practice. Forensic science incorporates challenging situations which might emerge in everyday practice. These situations arise from a number of factors:

- The unanticipated nature of the crime scene which results in unforeseeable practice settings.

Forensic science has commonly accepted guidelines in crime scene processing (Horswell, 2004). These guidelines illustrate some common features in the way offenders commit their offence. However, crime settings and circumstances cannot be foreseen for two main reasons. The first reason is the variability of the site and circumstances of a crime scene. Any place, under any circumstances, could be a potential scene of a crime (Horswell, 2004). For example, a crime scene may vary from a dark and humid basement, a deserted bush site which is hundreds of miles from a metropolitan area, a room in a 5-star hotel, to any place one may or may not expect as long as such a place is accessible by humans.

> *Forensic science practitioners work in hard and unusual situations. It might be unusual to photograph a crime scene in a badly lit corridor 2 o'clock in the morning... but that's part of the job nature*' (EP2, p12).

The second reason is the complexity of human nature (Kelly, 1999) which is hard to be anticipated in some instances. Human nature is the main contributor in the creation of a crime scene. Offenders at a crime scene may hesitate or act in an unexpected way. Consequently, victims as well may react in an unpredictable manner. Such unpredictable actions by the offenders and reactions by the victims may create crime scene settings which are similar, slightly different, or completely different from what are prescribed in books.

- The nature of the crime scene which demands in many instances the communication and cooperation between personnel of different backgrounds and professions.

Crime scenes often demand the contribution of various personnel coming from backgrounds and possessing different mindsets. These personnel are required to cooperate with one another in exchanging information and opinions. Such cooperation is complex especially when the cooperating practitioners are from very different areas and backgrounds. For instance, PP4 who is a vehicle examination officer described a communication between him and a forensic chemist on one of the occasions:

> *There are some cases of suicide and homicide we can't see whether the vehicle has caught fire because of internal heat or planned fire… we look at the mechanical side of the fire to the point, where then comes arson and there is someone to look at it and say it's an arson vehicle, that's when the arson chemists come in and there will be some formal collaboration. For instance, if I find out that it's a fuel fire, my opinion would be that fire started because of this, because of the mechanical damage, the arson chemist would say there is an accelerant or the engine there caused the fire, and we would be talking to each other …* (PP4, p.17).

Collaboration between a vehicle examination officer, who was initially a mechanic and who lacks any scientific background, and a forensic chemist, who is a scientist and is at least a holder of an honours degree in chemistry, may not be spontaneous and easy. It may as well seem very challenging to have a scientific communication between a crime scene investigator, who is an early school leaver who joined the police force and then the forensic science services, and a forensic pathologist, who studied around 12 years post-schooling to become a general medical practitioner first and then a specialist in forensic medicine.

- The communication of scientific results, analyses, and opinions to non-scientific beneficiaries.

  The ultimate aim of any forensic practitioner is to have his/her presented evidence, analysis, and/or opinion considered by the court and the jury. Communication of scientific results and opinions, including scientific terms, theories, probabilities, and perceptions, to non-scientific recipients: judge, jury, and legal practitioners is a complex and challenging task. However, it is a vital task in 'the judicial game'. From a judicial perspective, there is no value for any scientific results/opinions if such results/opinions cannot be communicated in a simple, clear, and, straightforward manner so that the plainest person in the jury would understand it (EP1, EP2, AP3, and AP4). Putting all the complicated scientific terms and sophisticated scientific language in an easy to understand plain language is 'a very challenging task, but it is one of the major factors of success for a forensic practitioner in a court of law' (AP3, p.4).

Exemplar 2 presents the most major complexities embedded within forensic science practice as reported by the majority of the participants. Hence, the nature of forensic science practice requires forensic practitioners to be able to cope with and manage such challenges and complexities. This will be the focus of Exemplar 3.

<u>Exemplar 3</u>

Forensic science practice incorporates challenging situations and complex problems. These situations and problems demand that forensic science practitioners be critical in everything they do in their everyday practice. Forensic science practitioners need to be critical in their thinking, problem solving approaches, and communication.

In managing the unexpected and challenging nature of a crime scene, forensic practitioners need to rely on their experiences and forensic sensibility (exemplar 1) of crime scene settings and critically link such experiences and awareness to the current crime scene they're investigating. In such a critical linkage, they can identify whether or not 'the circumstances of the scene sit right... and be able to prove or disprove [their] suspicions and manage those unusual crime scene settings' (PP2, p3). In order to be able to critically link experiences and aesthetic awareness to the crime scene setting in task, forensic practitioners 'should have an impartial mindset… they need not to jump into conclusions… they need to bring up a hypothesis and test it instead of trying to support it without critically verifying it' (EP2, p14).

Forensic practitioners need to be critical thinkers in their communication tasks on the crime scene, in the laboratory and at court. On the crime scene, forensic practitioners need to be critical in communicating with experts of different fields, backgrounds, and mindsets. For instance, a forensic chemist needs to communicate more in a technical language when communicating with a sworn police member attending a crime scene versus a more scientific language when dealing with a forensic biologist or pathologist. In the laboratory, practitioners need to critically communicate with their colleagues and supervisors the results they have obtained and the basis for such results. In court, forensic practitioners need to be critical in paraphrasing their sophisticated scientific language into a simple and plain language understood by all the non-scientific recipients: judge, jury, and legal practitioners. They need to be critical in their defensibility of their opinions and the basis of such opinions.

> *Practitioners have to be capable of producing much clearer and more defensible opinions... forensic scientists are required to present the opinion and the basis for it in a pure logical and competent manner and be able to deal with sometimes hostile, sometimes quite unclear cross examination aiming to undermine the quality of the work or the weight of the expressed opinion... they need to ensure that the tribunal understands not only the opinion itself, but also the basis for it… I think it's important that the scientist ensures that they properly understand the questions from which they're been asked to express opinions before they embark on the task … there needs to be good communication I think, between the scientist and the legal practitioners... to ensure that the best possible presentation of the evidence can be achieved and the degree of humility can go long way on both sides in that kind of relationship… I think it is important that each scientist is prepared to listen to other opinions… and be able to accept criticism of their own work… it's the way in which the practitioner presents in the witness box in front of the jury which ultimately determines the outcome of the case* (AP4, p8).

Exemplar 4

Theme 4 emphasised that forensic science practice seems to be segmented between "the more vocational and less scientific" field practitioners and "the more scientific and less vocational" laboratory practitioners. These differences have been asserted by Horswell, who argues that field practice has been often conducted by sworn police officers whose training was largely informal and technical when compared to the formal scientific training undertaken by laboratory practitioners (2004).

Further exemplification of Theme 4 suggested that forensic science practice does not possess a major community of practice similar to other professions such as engineering and medicine. This is attributed to a number of reasons:

- the nature of forensic science practice varies between field and laboratory practice with respect to the prerequisites of employment, training, assessment, and accreditation:

  > *Currently there are differences between fieldwork and laboratory work... [starting] with the prerequisites for employment, standards applied, and many other things, most importantly the amount of science used… the amount of science used in the field is scarce when compared to that used in the lab…* (EP3, p12).

  > *There is segregation between the two practices … The police people [crime scene examiners] are not operating under an accredited laboratory … their training, standards and assessment requirements are different from those of lab practitioners* (EP4, p14).

- The identity of laboratory practitioners, who are often civilians, is different from that of field practitioners, who are often members of the armed forces. This is emphasised by literature (Gaensslen, 2003; Horswell, 2004) and supported by the fact that the participating field practitioners in the research interviews were all sworn police officers (PP1, PP2, and PP4), whereas the participating laboratory practitioners were all civilians (PP3, PP5, and PP6).

- The jobs incorporated within the forensic science field are different to an extent that forensic practitioners of different jobs think differently.

> *Although I wish so much that at least all forensic professional people would think the same way, the reality is there are a lot of different professions within forensic science. I mean if you are a forensic chemist doing toxicology analysis or you are someone doing crime scene, you know, although you should think the same way, the jobs are very different, the requirements to enter in the jobs are different* (EP3,p12).

- Segmentation in forensic science practice does not only exist between field and laboratory practice, but also extends to cover the different specialisations and professions incorporated within the forensic field practice. Each of the explicit forensic specialities (e.g. fingerprinting, document examination, and firearms examination) has its own accreditation body, professional organisation, and professional journals, independent from one another and from those of other forensic specialisations (Gaensslen, 2003).

Hence, it is hard or nearly impossible for forensic science to possess a homogenous or major community of practice. Instead, forensic science practice seems more to be a set of minor communities of practice which require different educational backgrounds, training and accreditation processes, mindsets, and social identities. However, such communities of practice operate under the one theme: relating science and science applications to law.

Summary

The research identified a general set of four practice exemplars which may be used to identify features of forensic science practice and create an interconnecting framework of common practices amongst all the professions and areas incorporated within forensic practice. Exemplar 1 stressed the forensic sensibility of the crime scene which needs to be possessed by all forensic science practitioners despite their areas of expertise. Exemplar 2 illustrated the challenging aspects of forensic science practices which contribute to the complexity of the forensic science field. Exemplar 3 responded to exemplar 2 by emphasising the requirement that forensic practitioners need to be critical in their everyday practice, particularly their thinking and communication, in order to be able to manage and cope with challenges in forensic science practice. Finally, exemplar 4 elaborated theme 4 by giving examples as to why forensic science is unable to possess a major community of practice, but only a set of minor communities of practice which operate- to an extent- independently from one another.

6.4.3- The Education which Responds to the Nature of Practice and Emphasises the Identified Practice Exemplars

In a similar approach to that adopted in Chapter 5, this chapter examines the various groups of participants as social groups (Bernstein, 2000). In this subsection, the stance of each of the group of participants from forensic practice conceptions is explored. These stances are important in discussing how forensic science education responds to the nature of forensic science practice. Then, the complexities which face forensic science education in emphasising the forensic practice exemplars are discussed.

<u>Forensic social groups</u>

Data analysis in this chapter clearly suggested the emergence of two distinct major social groups within the forensic science practice: laboratory practitioners and field practitioners. The distinction between these two forensic social groups is summarised in the Table-6h.

	Laboratory Practitioners	**Field Practitioners**
Nature of the tasks	More scientific	More vocational (technical)
Mindsets	Scientific	Military (police)
Scope of Practice	Unrestricted access to both laboratory and field work	Restricted access to laboratory work

Table-6h

The notion of the existence of various social groups or power groups within forensic science will be further developed in chapter 8, after this notion is examined from an identity perspective in chapter 7.

Complexity in Introducing Forensic Science Education

Based on the identified practice themes and exemplars, introduction of forensic science education in tertiary education prior to employment might be complex. A number of challenges face the introduction of forensic science education at universities:

a) The curricular organisation of higher education programs normally requires cooperation between course coordinators and the community of practice relevant to the profession(s) aimed by these courses (Cullingford, 2004, Burgen, 1996). However, in the case of forensic science, there is no one major community of practice, through which all accreditation processes, training programs, and practice organisational frameworks are managed. Instead, there exists a minor community of practice for each speciality area in forensics. This makes the cooperation with all these minor communities of practice a problematic process.

b) Emphasising practice exemplar 1 within a tertiary forensic science course is difficult. The development of forensic science sensibility requires access to real crime scenes and crime scenarios. Such an access is often restricted for civilians prior to employment in a forensic science centre/agency. Hence any education in this respect without access and exposure to real crime scenes and scenarios remains hypothetical rather than practical.

c) Forensic science practice is of a complex and challenging nature (exemplar 2). Hence, one of the expected tasks of a forensic science course is to equip students with graduate capabilities (critical thinking and communication) which enable them to manage and cope with everyday forensic practice challenges. Again these capabilities (exemplar3) require students to have access to: a) crime scenes, where they are present with different scenarios and challenges and where they can communicate with the different personnel attending such scenes, b) forensic laboratories, and c) trials. Apart from court visits, access to crime scenes and forensic laboratories is often restricted to law enforcement personnel.

These challenges which face forensic science tertiary education will be further discussed and explored in chapter 9, after consideration of the complexity issues which might challenge forensic science education from an identity perspective in Chapter 7.

Summary

In this subsection, the research identified the social groups that exist within the forensic science practice. The research also identified the challenges which face forensic science tertiary education. The first challenge is mainly the existence of several minor communities of forensic practice which makes curricular cooperation with such communities complicated. The second challenge is the restricted access of civilians to real crime scenes and forensic laboratories, an issue which makes emphasising practice exemplars 1, 2, and 3 in a forensic science course impractical.

6.5- Chapter Summary

This chapter was organised and presented in four sections. The first section, introduced the aim, structure, and relation with the preceding chapter (chapter5) and the following chapter (chapter7). This chapter is a qualitative analysis of forensic science practice as being one of the three determining factors of forensic science education: knowledge, practice, and identity.

The second section presented four identified categories of description relating to forensic science practice. The stance of the participating groups from each category of description was addressed in an independent subsection.

The third section conducted inter-categorical analysis within each practice category. Such analysis took the form of a conversation between the perceptions of each group of participants in regard to each category of description. Such conversation allowed the observation of each practice category not only from the perspective of each individual participating group, but also as the summation of the perceptions and experiences of the three groups of participants.

The fourth section presented four cross-categorical themes relating to the nature of forensic science practice. Such identification was facilitated through the implementation of a pedagogical discourse across the inter-categorical practice attributes identified in the third section. Further exemplification of the themes created a general set of four practice exemplars and generated implications for forensic science education from a forensic practice perspective.

As a whole, this chapter presented participants' conceptions of forensic science practice and an analysis of these conceptions. The following chapter provides a presentation and analysis of participants' conception of forensic science identity.

Chapter 7: Conceptions of Forensic Science Identity

7.1- Introduction

This chapter is the last of three chapters presenting data analysis of the second stage of the research methodology. Previous chapters 5 and 6 had already presented and analysed data relating to forensic science knowledge and practice. This chapter presents conceptions relating to forensic science identity.

Identity, from the research perspective, is represented by the status, image, occupational outcomes, and shape of forensic science as both an academic field of study and a profession. Chapter 7 presents and analyses data collected from the perceptions of the three groups of participants about forensic science identity.

In a similar approach to Chapters 5 and 6, data analysis in Chapter 7 is organised in three sections, where analysis starts with coding of main forensic science identity conceptions (section-7.2), progresses with inter-categorical analysis in relation to each identified category of description (section-7.3), and concludes with cross-categorical synthesis (section-7.4).

Cross-categorical comparisons across the identified inter-categorical attributes generate five themes relating to forensic science identity. These themes are further explored by the writing of a set of five exemplars. Finally, implications for forensic science education from an identity perspective are presented. An organisational chart representing the various stages of data analysis process in this chapter is presented in Figure-7a.

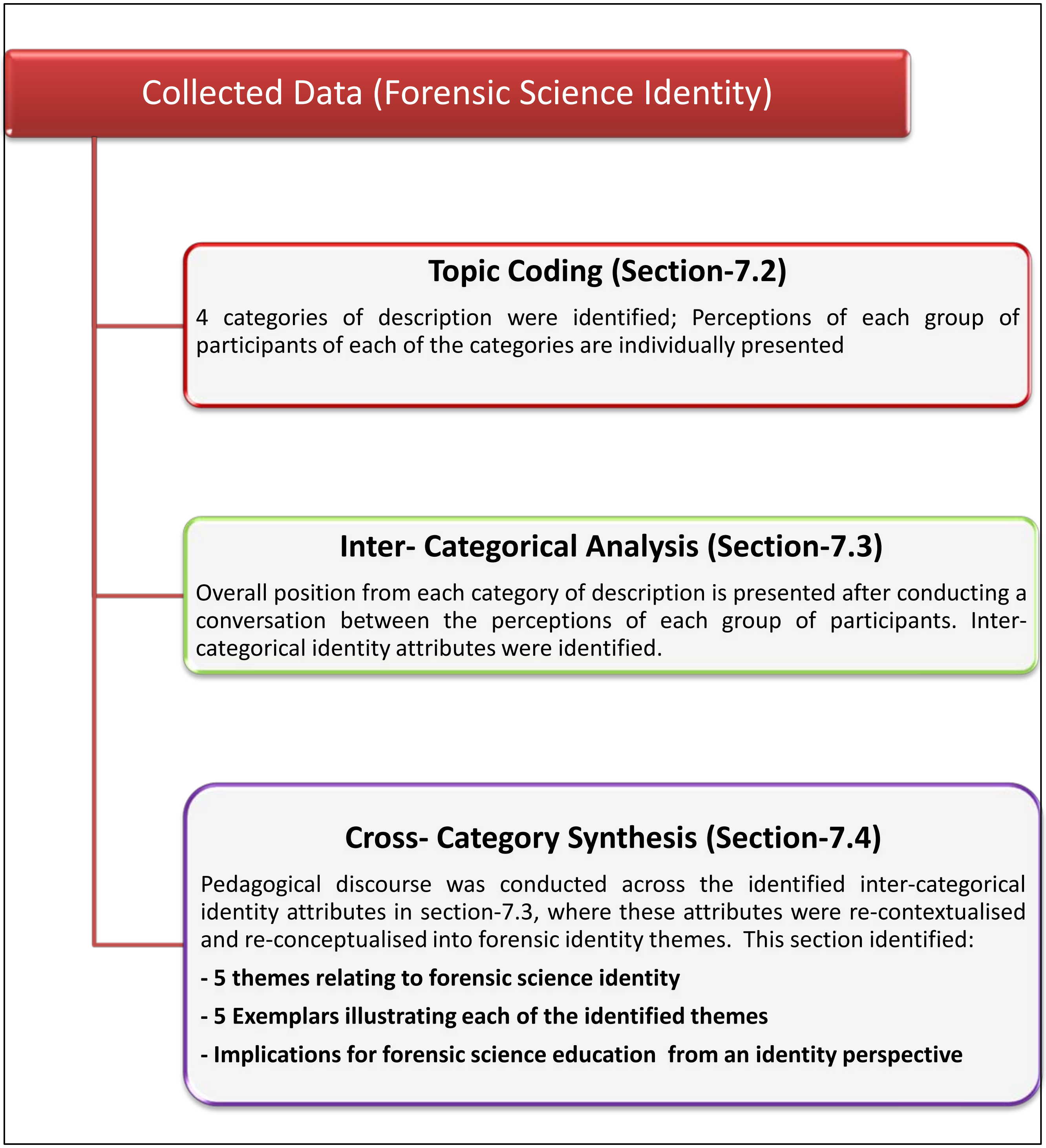

Collected Data (Forensic Science Identity)
Topic Coding (Section-7.2)
4 categories of description were identified; Perceptions of each group of participants of each of the categories are individually presented
Inter- Categorical Analysis (Section-7.3)
Overall position from each category of description is presented after conducting a conversation between the perceptions of each group of participants. Inter-categorical identity attributes were identified.
Cross- Category Synthesis (Section-7.4)
Pedagogical discourse was conducted across the identified inter-categorical identity attributes in section-7.3, where these attributes were re-contextualised and re-conceptualised into forensic identity themes. This section identified:
- 5 themes relating to forensic science identity
- 5 Exemplars illustrating each of the identified themes
- Implications for forensic science education from an identity perspective

Figure-7a

7.2- Topic Coding: Categories of Conceptual Identity Attributes

Four categories of description representing the major qualitative conceptual identity attributes of forensic science are presented in this section. These identity categories were identified by the responses of the participating interviewees. For each category of description, the responses and perceptions of each group of participants relating to that category were presented in individual subsections. Inter-categorical analysis, amongst the perceptions of the three groups of participants in each identity category, is conducted in the following section. The four identified categories of description relating to forensic science identity are:

- Category 1: Multiplicity of Factors Influencing Forensic Science Identity
- Category 2: Structural Identity of Forensic Science
- Category 3: Forensic Science Identity in comparison to other Professions
- Category 4: Forensic Science in Tertiary Education

7.2.1- Multiplicity of Factors Influencing Forensic Science Identity

In this category, the research identified the range of factors which impact forensic science. Such an impact may be major, minor, or peripheral. The factors listed as potentially influencing forensic science identity in the interview questions (Appendices D, E, and F) are: media, judicial system, police, politicians, technology, forensic practitioners, forensic educators, and the general public.

To better present each participant's position from the list of factors of previewed impact on forensic science identity, numerical values (2, 1, 0, and -1) were used. These numerical values present the strength of impact, if any, of each factor as emphasised by each participant. They are not a measure of statistical significance. The representation of each numerical value is addressed in the following table (Table- 7a).

Numerical Value	Representation
2	Emphasised as a major impact/influence on forensic identity
1	Emphasised as a moderate impact/influence on forensic identity
0	Neutral, undecided, or very minor impact/influence
-1	No impact/influence on forensic identity

Table-7a

A frequency table addressing each participant's emphasis of the list of potential influence factors is presented for each group of participants. At the end of each table, an average frequency is calculated for each of the listed factors to show the overall impact of each factor as reported by each group of participants. Following each frequency table, quotes, which are the most significant, are reported for each group of participants. These quotes are presented in summary tables.

7.2.1.1- Multiplicity of Factors Influencing Forensic Science Identity as Perceived by the First Group Participants

Perceptions of the participating educators of the listed factors of potential impact on forensic science identity complemented in certain instances (e.g. media) and clashed in others (e.g. forensic educators). Each participant's position towards each of the listed factors is presented in the following table (Table- 7b).

	Media	Judicial System	Police	Politicians	Technology	Forensic Practitioners	Forensic Educators	General Public
EP1	2	1	1	1	1	1	1	1
EP2	2	1	1	1	2	1	1	1
EP3	2	2	2	2	2	1	2	1
EP4	2	2	2	2	1	2	1	2
Average	**2**	**1.5**	**1.5**	**1.5**	**1.5**	**1.25**	**1.25**	**1.25**

Table- 7b

The most significant quotes, in regard to each of the listed factors are presented in Table-7b*.

	Quote(s) of Most Significance
Media	*I think the media, the media and the media… the standards of our work were raised partly because of media focus on some bad cases like the Chamberlain… the CSI show has raised the expectations particularly in terms of turn out times, we're not that quick, we don't operate like that, one person doesn't do everything because we tend to be specialised... there was that murder of two sisters... it took the forensic practitioners 3 days to get the DNA done which was pretty good because of all the bureaucracy, procedures, and standards to make sure that they've got things right but eventually forensic practitioners were criticized by the police because they've seen it on CSI done in 48 minutes and that's a true story... there is a real down side too because not all of the CSI is rubbish, a fair bit of it has some element of truth in it, and we've certainly found the bad guys using techniques to stop us finding forensic evidence that we haven't seen before…* (EP2, p28).
Media(cont.)	*Media is probably the biggest factor in shaping forensic science in people's mind, the people with absolutely no idea of forensic science... I think it's not black and white it's both. I think the positive attribute is that for the first time forensic sciences had a very high profile. So people have been interested in forensic science, on the negative side these shows are very inaccurate and it creates a lot of high expectations about forensic science...* (EP3, p29).
Judicial System	*Under different judicial systems and different jurisdictions things are done differently* (EP4, p30).
Police	*The AFP has the political weight and the money... they are very strong stakeholders and with no reasonable doubt they contribute to the forensic science image* (EP3, p29).
Politicians	*Politicians have a big influence or can have, because they set the criteria... they set the legislation which allow or restrict things to be done... That will shape how we do things and to what level things are done from a forensic perspective… they also control the funding…* (EP4, p30).
Technology	*Technology solves a lot of cases that we wouldn't have solved, or even looked at...* (EP2, p12).
Forensic Practitioners	*The better forensic practitioners apply their knowledge... the better the image will be because community identifies the practice by outcomes* (EP4, p29).
Forensic Educators	*Research is another driver especially in the academic side, also by having forensic science conferences of higher standards all the time, you build up a portfolio of research, you shape some kind of identity here as well* (EP3, p28).
General Public	*Community has big expectation of forensic science... the general public expects forensic scientist to be knowledgeable, ethical, and precise. These expectations contribute in forensic science identity* (EP4, p30).

Table-7b*

The impact of the media was reported by all first group participants as the most influencing factor on forensic science identity. Such influence results in advantages and disadvantages. Advantages are mainly the development of the forensic practice, where media scrutiny in many cases of justice miscarriage has played a vital role in such a development. Another positive aspect is the high profile forensic science enjoys in public. Media focus has raised public awareness of forensic science. However, disadvantages arise because public awareness of forensic science is not merely based on facts, but on a great deal of fantasy, fiction, and exaggeration which leaves the audience with false impressions and unrealistic expectations about what forensic science can and cannot do. Another negative aspect comes down to the publicising of forensic science knowledge through media or universities. Such knowledge may be misused by current and potential offenders in removing, damaging, and/or contaminating exhibits and prints left at the crime scene.

The judicial system was also reported as a major impact on forensic science identity. This is because forensic science is practiced differently under different jurisdictions. Similarly, politicians have a strong impact on forensic identity, because they are the policy makers of legislation, acts, guidelines, and codes under which forensic practitioners operate. A heavy political weight is also given to the police who contribute to policy making and control of finance. Police were reported as major stakeholders in forensic science.

Technology impacts forensic science in a positive way, because many of the cases which forensics can presently investigate and solve would have remained incomplete without the advances in technology.

As for practitioners themselves, they do shape the forensic identity in a manner proportional to how ethical, proficient, and competent they are. Forensic science educators contribute in shaping the identity in the quality and quantity of conducted research and organised conferences and seminars.

Community perceptions of forensic science are very important. However, their perceptions are mainly shaped by media focus on forensic science.

7.2.1.2- Multiplicity of Factors Influencing Forensic Science Identity as Perceived by the Second Group Participants

Participating practitioners expressed their perceptions of the list of factors of potential impact on the forensic science identity. Each participant's position towards each of the listed factors is addressed in Table- 7c.

	Media	Judicial System	Police	Politicians	Technology	Forensic Practitioners	Forensic Educators	General Public
PP1	2	1	1	1	1	1	-1	1
PP2	2	2	1	1	2	0	-1	1
PP3	2	2	2	2	2	0	0	1
PP4	2	1	1	1	1	0	-1	1
PP5	2	1	1	0	2	1	1	2
PP6	2	2	2	1	2	0	0	1
Average	**2**	**1.5**	**1.33**	**1**	**1.67**	**0.33**	**-0.33**	**1.17**

Table- 7c

The most significant quotes, in regard to each of the listed factors are presented in Table-7c*.

	Quote(s) of Most Significance
Media	*I think media drives the general public's and politicians' perceptions of forensic science; it holds the image and can change perceptions of forensic science… unbelievable* (PP1, p21). *Certainly the CSI shows popularised forensic science to such a point that many of the young people at university want to get into it… the forensic courses took off like a rocket... these shows also popularised us [forensic practitioners]…The impression you get can be when you go outside and having people saying "can I get your autograph"… they'll look to you like a hero: you're honest, you never lie, you're always unbiased, you always look at both sides of the equation, you always have a solution for every problem that is actually what is*

Media (cont.)	*reflected on TV and is shaping public perceptions…* (PP4, p28). *Yeah I think the media plays the large role… the T.V. shows can be really unrealistic… many assume if there is no evidence, then there must be a different approach, sometimes there is nothing that we can do… We've had instructions coming to C.S.I things and you don't know what that means, you don't know what they [police] want, they just think that you can do magic, fix anything, and find the answer to anything when there are limited things you can sometimes do… sometimes lawyers or the court don't understand how long an analysis can take, again that could be related back to those CSI type shows where with a press button results come up straight way… everything we do can be scrutinised and being kind of exposed to the media, so if you do something wrong there is that risk that it can be out there; you can open the paper and your name can be there saying that you stuffed up; you have to be accountable for things…* (PP5, p23). *Jury expectations… I know police officers who have said that if a case doesn't involve DNA, then, the jury thinks there's something wrong with it and they're less inclined to find someone guilty… I think they're watching too much C.S.I… Certainly the T.V. shows create unrealistic expectations to the extent where there was a police on the phone who have actually said to me: "how come it takes you guys so long to get a DNA profile when I've seen them get a result on C.S.I. within a 20 seconds", I mean they're half joking when they say it, but in the back of their mind it is like: "why does it take these guys so long when I've seen it done quicker". On the positive side media can be very critical and influential if we commit mistakes or misuse our power...* (PP6, p26).
Judicial System	*The judicial system certainly has an impact on forensic science… they're actually a driving factor of forensic science work…* (PP2, p26). *I think courts have a strong influence because the work we're performing is ultimately for them and if they request that the information be presented in a certain way, then we need to listen to that… judges are in fairly powerful position, they can have a large impact on the way we do our work by some of their decisions (*PP3, p25).
Police	*They would have a big impact because we fall under their umbrella and we have the most contact with them… we're often working under their guidelines and their rules and conditions* (PP3, P24). *They're the ones that bring in the evidence and take it back to the court… they try to get the convictions; they shape it in that they tell us what they want…whether we give them the answer they want or not the evidence tells of that, but they point out what they want us to find, so the majority of our work is based upon what they request* (PP5, p25). *Unlike the police, we have minimal contact with the public; they use our information in their interviews, so they translate the results we obtain to the public…* (PP6, p29).

Politicians	*Yes I think politicians could definitely have an impact… in the end they're the decision makers and they are in a position of authority … they're also the ones controlling the funding* (PP3, p24).
Technology	*Things are always improving: new machines, improvements on current machines to become more sensitive… new techniques and new methods are set and are able to identify a certain tissue type for example… new ways of discriminating between individuals and between object and without the technology, forensic science would struggle…* (PP3, p26) *In my area, the new technologies would have massive impact on the landscape of forensic science… the lab has gone from I think about 10 staff to about 70 staff in 10 years and the amount of work that comes into the laboratory as a result of the improvements has grown exponentially … as the technology improves it can have more impact on a case and therefore the law enforcement agencies are more inclined to use it...* (PP6, p22).
Forensic Practitioners	*We do not have any significant impact because confidentiality is a big part of what we do, so we don't go and talk about it, we do it, we keep it quiet even with our own families, nobody knows what we're doing until it goes to the court room* (PP2, p25). *We're small closed sort of a group, the effect would only be through media attention from case reports or what police release* (PP4, p28). *We do impact the identity by the way that we do our work and the knowledge underpinning this work…* (PP5, p24).
Forensic Educators	*The impact is mainly through the research they conduct or supervise…* (PP6, p30).
General Public	*The community does have an impact… but where do they get their perceptions from? From universities, or politics? I don't think so… it's more of the media and T.V. programs* (PP2, p26). *The way society perceives forensic science impacts the way we do things; it makes us accountable; they're the people that sit on the jury* (PP5, p24).

Table-7c*

The second group participants argued that media drives and shapes public perceptions and expectations of forensic science. Such influence extends to cover many members of the police who work closely with forensic scientists, where these members possess unrealistic expectations of what forensic scientists can do and the time frame it takes to complete a certain task. These unrealistic expectations affect the jury as well in one way or another, as many of those called to serve on a jury have watched or are still watching one of those fanciful TV shows. Media has also popularised forensic science courses and has increased the number of students enrolled in those courses. On the more positive side, media follows up and scrutinizes the work presented by forensic scientists during trials. Hence, such a scrutiny makes forensic scientists accountable for their work.

The judicial system impacts forensic science identity because ultimately the whole aim of any forensic work is to relate science to law. Courts have the power to request that forensic work is conducted or presented in a certain way. Court decisions can impact forensic science practice and demand that changes/amendments are done accordingly.

Police impact forensic science because in many jurisdictions forensic practice is conducted within police departments under the police’s rules and guidelines. Moreover, in many jurisdictions, police still collect and bring in the evidence to forensic centres/laboratories. This demands direct interaction between forensic practitioners and police members. Through this interaction, the police can request forensic practitioners to concentrate more on certain issues rather than other issues. Because forensic scientists have minimal contact with the media, police often represent the pathway through which forensic science information, data, and updates are exposed to the media and the general public.

Technology has created advances in the forensic field. With the use of new technologies, forensic science can examine features of crime scenes and produce evidence which was not previously possible.

The minimal exposure of forensic scientists to media and the general public, due to strict confidentiality requirements, restricts the influence of forensic practitioners on forensic science identity. The ways through which forensic practitioners can impact forensic identity are restricted to how proficient they act, how ethical they are, and how active they are in exchanging expertise and information through national and international conferences.

The general public was reported to have a major influence on forensic science identity. However, such an influence mainly results from that of the media.

7.2.1.3- Multiplicity of Factors Influencing Forensic Science Identity as Perceived by the Third Group Participants

The participating members of associated professions expressed their views about the factors they believe that may/may not impact forensic science identity. Each participant's position towards each of the listed factors is addressed in Table- 7d.

	Media	Judicial System	Police	Politicians	Technology	Forensic Practitioners	Forensic Educators	General Public
AP1	2	1	1	1	1	1	0	1
AP2	2	2	0	2	1	0	-1	2
AP3	2	2	2	1	1	0	0	1
AP4	2	2	2	2	1	2	1	1
Average	**2**	**1.75**	**1.25**	**1.5**	**1**	**0.75**	**0**	**1.25**

Table- 7d

Quotes, which are the most significant in this regard, are presented in the Table-7d*.

	Quote(s) of Most Significance
Media	*I was interviewed by a journalist the other day and she just wanted to talk about the Halifax and the CSI shows: "oh but you must be like CSI and Halifax" [journalist]; "No, not like C.S.I. and Halifax" [AP1]… but even so she [journalist] couldn't quit keep referring to Halifax in the article... media effect is so glamorous, it can perhaps not tell the realistic image, and we've had for instance a housing worker who was not suited to be in that position and, he said: "I think I might go to forensic science, I've always been good at science and I'm talented to do"… TV shows keep creating false expectations...* (AP1, p16). *TV shows, absolutely. I think most people's perceptions of a forensic scientist as someone who can do the whole lot which is not true… generally most people would've never met a forensic scientist, would never have any experience with what they do, and the only perception is available from what is seen on the TV…* (AP2, p17)

	Certainly in the last 25 years there has been much greater interest in forensic science as a result of television programs and the huge number of best selling crime novels… it influences public opinion with lot of people watching these programs… I would place great weight on what is seen on television in terms of affecting jury's expectations… (AP3, p18)
Judicial System	*I think forensic science's strength is proportional with that of the court system… unless the court system has strength and integrity, forensic science doesn't have the prospects of flourishing… any forensic scientist that seeks job satisfaction would find it very difficult to achieve that in a court system that is corrupt. Well I think that we're capable of doing forensic scientists a service in allowing them to present themselves, by asking them questions in a way which enables them to present their case clearly and logically; we're also capable of doing them a great dis-service by doing the job badly…we can make life very uncomfortable for forensic scientists who have done their job less than well… they'll learn from their errors and come back all stronger the next time and ensure that they've covered all the bases…* (AP4, p14)
Police	*The close relation between police and forensic practitioners may negatively impact the practitioners' image: being impartial scientists, biased to the party calling them, controlled by the police... it may destruct the whole image...* (AP4, p17).
Politicians	*They impact through managing resources and funding...* (AP3, p18).
Technology	*Technology, yeah I think so, it's just the way the speed we are able to do things in comparison to things done ten years ago* (AP1, p16) *Technology allows them [forensic practitioners] to do their job better, this will provide more support to investigation… sometimes technological advancements create a problem... a lot of the investigators have too high expectations; and that sometimes comes about because we have a new development… I remember going back a number of years where DNA technology was first introduced in this State. Many were saying: "We will be able to solve 90% of the crimes through DNA" but in reality the number of times quality DNA has been taken from exhibits is extraordinary low…* (AP2, p12)
Forensic Practitioners	*Certainly impacting… and if they demonstrate less than what is required, then they can very adversely affect the whole trial…* (AP4, p18)
Forensic Educators	*They [forensic educators] influence by how much they engage into research… conferences and meetings…* (AP4, p18).
General Public	*I suppose they do, because they're the ones who hold the perceptions and probably they believe these TV shows…* (AP2, p17).

Table-7d*

The third group participants asserted that media is a major impact on forensic science identity as it drives and shapes public perceptions, amongst whom are the members of juries, about forensic science. Media has created false impressions and unrealistic expectations of forensic science as a profession and forensic scientists as practitioners.

The judicial system was reported to have a substantial influence on forensic science. The identity of forensic science as a profession is directly proportional to that of the judicial system it falls within in terms of strength, integrity, and proficiency. The courts represent the sites where all the forensic knowledge, expertise, and analyses are displayed and assessed.

Politicians impact forensic science in terms of the availability of resources, funding, and finance. The scarcity in resources and funding impacts the forensic science practice and ultimately the legal system by leaving forensic science centres almost inactive; struggling with backlogs and priority setting.

Other reported factors of impact were the police, general public, and technology. The relationship of the police to forensic practitioners may negatively impact them by creating the perception of being impartial. Technology impact is more related to the speed of work where forensic tasks are currently completed much faster than before. The general public's impact on forensic science is a major one, but it comes as a result of media impact. Practitioners themselves affect the identity when it comes to the way they carry out their work.

7.2.1.4- Summary of the First Category of Description

The first group participants emphasised that the media have the most influence on forensic science identity, followed by technology, the judicial system, police, and politicians. The impact of the general public is important but remains driven by the media. Forensic practitioners and educators affect forensic identity but to a lesser extent.

The second group participants considered the media and technology to be the most influencing on forensic science identity. On the other hand, the majority of these participants consider both forensic practitioners, and forensic educators to be the least influential on the formation of forensic science identity, where practitioners possess minimal public exposure due to strict confidentiality requirements, whilst educators possess minimal influence.

The third group participants asserted the media and the judicial system to have the greatest affect on forensic science identity. They considered forensic educators to be the least influential.

7.2.2- Category 2: Structural Identity of Forensic Science

In this category, the research identified the structural identity of forensic science. In many jurisdictions, forensic science still operates as one of the police divisions either in dependent or semi-independent structures. In fewer jurisdictions, forensic science operates as a completely independent structure. The research attempted to identify the structural identity of forensic science through asking all the participants about their preference for the structure under which forensic science would best operate. Three structures were proposed:

- Dependent Structure: The forensic science facility is one of the police divisions with full management and leadership by the police.
- Semi-independent Structure: One of the police divisions but with semi-independence when it comes to management and leadership.
- Completely independent structure: a stand-alone entity completely independent from the police authority and entirely run by civilians.

For each group of participants, the preference of each interviewee in regard to the structural organisation of forensic science is reported in a summary table.

7.2.2.1- Structural Identity of Forensic Science as Perceived by the First Group Participants

The first group participants, when asked about the structure under which forensic science should operate, expressed various views. Each participant's position is addressed in Table-7e.

	Dependent Structure	Semi-independent Structure	Completely Independent
EP1		✓	
EP2		✓	
EP3		✓	
EP4			✓
Total	**0**	**¾**	**¼**

Table-7e

The majority of the first group participants argued for a semi-independent structure of forensic science. This semi-independent structure keeps forensic science as one of the police divisions, yet it gives forensic practitioners more flexibility and independence in conducting their work as scientists. Forensic science centres cannot run in total independence from the police departments, because they need to have strong linkages with the police. Police have ownership in the process of securing the crime scene, investigation, and arresting suspects. They often bring evidence to forensic centres and take it back to courts. Therefore, they are major players in the whole investigation-prosecution process. Nevertheless, forensic practitioners are scientists and should keep a distance from the police in regard to prosecution. This distance needs to be in favour of what the collected evidence reveals versus the contents of police intelligence. Forensic scientists are there to apply science and scientific knowledge and not to bring about prosecution.

> *The one thing about being with the police is that the police have responsibility from the beginning of the incident right to the end… Police have ownership…*

they have all the information, so the intelligence side is very important. They also have a very powerful infra-structure… so it's a very good organisation to work for. On the other hand, I think things go a little bit wrong at the end of the day where the responsibility of forensic scientists is to bring about evidence, to bring about good science, not to bring about prosecution. Forensic scientists are there for the justice system to make sure that the right people are before the court, if indeed there is any evidence to support that... a semi-independent structure would best facilitate such a relation between forensic practitioners and the police… (EP2, p29).

7.2.2.2- Structural Identity of Forensic Science as Perceived by the Second Group Participants

The second group participants possessed divided opinions about the structure which may organise forensic science. Participants' positions are reported in Table-7f.

	Dependent Structure	Semi-independent Structure	Completely Independent
PP1	✓		
PP2	✓		
PP3			✓
PP4		✓	
PP5			✓
PP6		✓	
Total	–	–	–

Table-7f

The participants, who argued against moving forensic practice from underneath the police authority, supported their argument by two main reasons:

- Forensic science needs to possess a very close link to the police because the police remain one of the major stakeholders of forensics. Hence, removing forensic science from within the police authority threatens this close link and decreases the efficiency of the work in presenting evidence and elements of a charge in front of a court.

> *To be outside the police umbrella is a disadvantage because you don't have your close links with your stakeholders who are mainly your police detectives; we liaise extremely closely with them* (PP2, p24).
>
> *The advantage of the lab [forensic laboratory] being under the police umbrella is that it can lead to better interaction between the two groups. Obviously we work very closely with the police and if we're in the same organisation like we have set up here, the interaction and the learning opportunities and the efficiency of work would be much better* (PP6, p29).

- Legislation in many jurisdictions restricts certain forensic areas (crime scene investigations, explosives, ballistics and firearms, etc) to sworn members of the police because such areas are of a quasi-military nature.

> *Legislation restricts the handling of firearms to sworn members of the police and requires that whenever there are firearms, they need to be investigated and examined by sworn police officers...* (PP4, p31).

On the other hand, a number of participants emphasised the advantages of having forensic science independent from the police. The emphasised advantages are:

- Civilians are more open-minded than police officers and they are capable of conducting their work with fewer assumptions and more objectivity. Managing a forensic science centre/agency from a civilian point of view independent of the police promotes the scientific nature and objectivity of forensic science practice.

> *I guess someone coming from outside of the police or military area is likely to have a bit more of an open mind perhaps and wouldn't make as many assumptions as someone who had a police or military background... the police may have their prescribed ways of doing things... from an outsider's point of view I think we would be able to promote ourselves*

and our work in a better light I think as an independent organisation or independent body that doesn't form part of the State Police... the police might not totally understand the bigger picture and they might not necessarily see everything that's going on at lower levels at the laboratory (pp3, p27).

- Managing forensic science independent from the police promotes its objectivity when it comes to presenting evidence in a court of law. Working within the same department as the police or under one of the police divisions will inevitably lead the defence to raise the issue of the bias of forensic practitioners in favour of the police and prosecution in setting the elements of a charge.

> *I have been asked numerous times about my work with the police: "how long have you been working for the police? How many friends you've got in the department?... "for this case have you worked with this member before... oh you went to the scene with him as well! He pointed out the car that he wanted you to look at! He asked you to look under the back seat!" so if we work in a separate department from the police, we can't get any accusations of standing on the side of the police than what we are now…* (PP4, p31).

> *I think one of the key things for me with forensic science is the whole idea of remaining objective and impartial... being housed outside the police would be an advantage and would alleviate any potential criticism: "we're only getting that result because we're paid by the police to do it" that sort of argument* (PP6, p29).

- Creating an independent scientific profile which reflects the nature of the forensic field and the identity of the forensic scientists:

> *We should be viewed as an independent science body or independent scientists… more of pure scientists… but the problem is that we are being considered a part of the police... this is kind of restricting us from having our own identity* (PP3, p29).

Regardless of the organising structure of forensic science, all participants, including those who argued for complete independence, asserted that there will always be a link with the police.

> *Obviously we do our work for the police in terms of what is involved in criminal matters; so there'll always be a link with police you'll never going to lose that* (PP3, p27).

At the end of the interview, each participating practitioner was asked if s/he considered herself/himself a scientist, police member, or a technician. The answers were divided between:

- Field practitioners who denied that they are scientists and preferred to be termed as police officers performing technical work for the judicial system:

  > *I would not say I am a scientist or a man of science… I am more of a technical officer … more of a police and judicial technical officer* (PP1, P23).

  and

- Laboratory practitioners who considered themselves to be first and foremost scientists, despite the fact that they are involved in legal processes such as expert witnessing:

  > *I actually see myself as very much a scientist first and foremost and yeah I guess to a certain extent my job involves being an expert witness, but that's just an extension of the science, so first and foremost I'm a scientist* (PP6, p31).

These different perceptions complemented each group's position from the structural identity of forensic science, where field practitioners tended more towards police-dependent structures, whereas laboratory practitioners tended more towards police-independent structures. These differences in perceptions and positions between these two power groups connect with Bernstein's notions of power and control (2000) which will be further discussed in Chapter 8.

7.2.2.3- Structural Identity of Forensic Science as Perceived by the Third Group Participants

The majority of the third group participants argued for complete independence of forensic science from police departments. Participants' positions are presented in Table-7g.

	Dependent Structure	Semi-independent Structure	Completely Independent
AP1			✓
AP2		✓	
AP3			✓
AP4			✓
Total	**0**	**¼**	**¾**

Table-7g

Participants AP1, AP3, and AP4 argued for complete independence of forensic science from police departments because such independence promotes impartiality and proficiency, minimizes work backlogs, and enhances funding and resources.

> *Well the greater the advantages are if they're independent… in this case you don't have the problem of impartiality or bias…* (AP3, p15).

> *I think it's much healthier to be independent of the police department. In my experience those that practice internally within police departments are less effective than independent practitioners, partly because they are often perceived to be biased and it is essential to have independent forensic scientists who are in a position to assess or re-assess… It is essential for the interests of justice that a body of scientists is available to individuals so that there is an alternative view that can be expressed in court counter to what might be totally wrong scientific evidence presented from the internally retained military or police forensic scientist…* (AP4, p16).

AP2, who is a senior police advisor, was the only interviewee in the third group participants who argued against the independence of forensic science from police departments. AP2 argued that, throughout his years of experience, he had not seen forensic scientists lose their credibility because they come from within a police-structured institute. Forensic science needs to be placed within the police structure, because police remain the biggest stakeholders in forensic science.

> *I've had that argument before and I don't think it has very much substance… for all my times in court going for a case, I've never seen forensic experts lose any credibility as a result of them coming within the structure under the state's police. I have heard sometimes defence barristers say if I want something analysed it's going to be done independently, I think there are other independent providers of that service… I'm comfortable with the structure as it is in our state now [semi-independent]… police is perhaps the biggest stakeholder of forensic science*… (AP2, p14).

7.2.2.4- Summary of the Second Category of Description

The majority of the first group participants argued for a semi-independent structure of forensic science which maintains strong liaison with the police, yet provides independence for forensic practitioners in their work.

The opinions of the second group participants were split between field practitioners, who tended more towards a police-dependent structure, and laboratory practitioners, who tended more towards a police-independent structure.

The majority of the third group participants argued for complete independence of forensic science from police departments. Such independence promotes the impartiality and proficiency of forensic scientists.

7.2.3- Category 3: Forensic Science Identity in comparison to other Professions

In this category, the research explored the identity of forensic science as a profession in comparison to similar applied science professions such as medicine and engineering. Each group of interviewees expressed their perceptions, identifying similarities and differences between forensic science and other professions.

7.2.3.1- Forensic Science Identity in comparison to other Professions as Perceived by the First Group Participants

The first group participants emphasised that there are more differences than similarities between forensic science and other applied science professions (e.g. medicine and engineering). As for similarities, forensic science resembles such fields in that practitioners need to possess good knowledge and apply it in a proficient and ethical way. This imparts on forensic science a high-profile identity.

> *I think most points would be equal to all those people that they all need good knowledge and they need to apply it in the right way… There are some professions that have a low identity, car sales people or real estate agents, probably because their practice is not always ethical or they do not stick to certain rules or they apply their knowledge in an unbalanced way, in a biased way. Engineers, forensic scientists and the like they have a good identity, a high profile one in the public… (EP4, p16).*

Forensic science, according to the first group participants, is different from other applied-science professions in many respects:

a) Forensic science is a 'very new area compared to medicine and other professions' (EP3, p12).

b) Forensic science suffers segmentation between laboratory work and field work unseen in other professions.

> *you could always argue whether you are an eye-surgeon or a GP but you will always have very much in common between different medical practitioners at least in terms of their education and knowledge base… in forensics the story is different, segregation does not only include field work and lab work but often covers the backgrounds, education, and perceptions of both groups* (EP3, p12).

c) The involvement of many professions and disciplines in forensic science makes it more of a combination of interest groups rather than a profession. This makes forensic practice unable to truly represent itself like other professions.

RACI[48] is focused on chemistry as a profession, where the ANZFSS[49] is focused on forensic science as an interest group. I would like to see ANZFSS becoming more professionally focused on forensics which would mean that the individual forensic practitioner would have to subsidize it, to the point that the profession could truly represent itself, which at the moment it can't.

d) Forensic scientists ultimately communicate their scientific results to a non-scientific audience (e.g. barristers, members of the jury, judge, etc), as opposed to many scientific professions.

We are different from the engineers and the chemists in that we have to communicate our results to a non-scientific audience... Other scientists they'll write reports but they will be scientific reports, they will be engineering reports- if we're talking about engineers, their reports will be scientific reports full of formulas and acronyms and technical words… where as the audience we're writing to are non-scientific people, when we explain our results it's the lay person, it's the jury (EP1, p14).

e) Forensic science is impacted by the individual jurisdiction under which it operates.

Some jurisdictions might allow the general public to seek certain forensic services, whilst others might not, this impacts the size of the forensic industry and the potential customers catered for... (EP4, p.21).

f) Forensic science is unique because it is the application of science within a legal context. The tool in forensics is scientific; however, the object of study is the legal.

I think it's an application of science and technology in a legal context…so it's applied science, but there are some specific issues, and specific questions in forensic science that don't necessarily exist in other fields that can make this discipline unique in terms of the object of study... so

[48] Royal Australian Chemical Institute

[49] Australia and New Zealand Forensic Science Society

> *say for someone doing DNA, they tend to think that DNA is the object of their study, now for someone doing forensic biology, DNA is the tool it's not the object of the study, just a tool which allows them to link between an object and a person* (EP3, p15).

7.2.3.2- Forensic Science Identity in comparison to other Professions as Perceived by the Second Group Participants

The second group participants also emphasised more differences than similarities between forensic science and other applied science professions. Forensic science resembles medicine and engineering in that ethics is vital for its success and survival.

> *I think ethics is very highly valued within forensic science and practitioners of similar fields like doctors and engineers…* (PP5, p26).

Another reported similarity is the use and application of scientific knowledge in mainly every aspect of their practice.

> *I guess we're similar in the sense that, at the end of the day, we apply all that scientific knowledge we learned in many aspects* … (PP6, p30).

However, Forensic science differs from other scientific professions in many respects:

a) Forensic practice is specific to every individual jurisdiction under which it operates:

> *The forensic community is a very small community and perhaps it's a bit different elsewhere… we're fairly isolated in many respects … forensic science practice is specific to every individual jurisdiction… we are restricted in our practice to the jurisdiction under which we operate...* (PP3, p28).

b) The nature of forensic science is unique as it mainly deals with crimes and offences:

I think we're different from other practitioners… the nature of the work…it's just all about crime; it's a unique area to begin with. I guess, the best way to express that, if you go to a party and you say: "hi I'm an engineer" it's like ok, if you go to a party and you say "I'm a forensic scientist", it's like "Huh ha, really?!" you always get some sort of a strong reaction... so yeah I guess, fundamentally we differ by doing unusual work in an unusual field (PP6, p30).

c) Forensic science work is ultimately done to serve the judicial system.

They [engineers and medical doctors] wouldn't be reporting on a regular basis to the court, we are court driven… our reports don't go to the head of the company... our reports primarily go before the magistrate to contribute in deciding someone's fate... (PP4, p32).

d) Forensic science lacks the independent image/profile of a stand-alone field. The forensic image/profile is always associated with that of the police.

The general image out is more so the police type of image… I think that's going to be a fairly hard image to lose, given all the work we do and where we are placed... (PP3, p28).

e) Forensic science caters for non-scientific practitioners to work within a scientific atmosphere.

Personally as myself, I don't have a science degree, yet I do work in forensic science… all engineers and doctors have gone to universities and hold science degrees… (PP4, p32).

7.2.3.3- Forensic Science Identity in Comparison to other Professions as Perceived by the Third Group Participants

The third group participants argued that forensic scientists are similar to engineers and medical practitioners in that they have a responsibility towards being knowledgeable, proficient, and ethical in their fields. This is because mistakes in these particular fields can be more costly than other fields.

> *Mistakes committed by medical practitioners and engineers can be costly in terms of human lives… Similarly forensic scientists have a peculiar responsibility because mistakes here can lead to miscarriage of justice… I think it is terribly important that forensic scientists are proficient and ethical in their conduct…* (AP4, p24).

Forensic science, according to the third group participants, differs from other professions in many aspects:

a) Forensic science is characteristic of each individual jurisdiction under which it operates:

> *Forensic practices that are conducted in a certain jurisdiction may vary when it comes to another jurisdiction…* (AP3, p22).

b) Forensic science involves a variety of disciplines and professions which in some instances have nothing in common but to serve the judicial system.

> *The judicial system invites all those different expertises and professions coming from different backgrounds… they sometimes have nothing in common but to serve the justice system* (AP3, p22).
>
> *All these practitioners of different backgrounds are like clusters... there are times when the clusters join together in terms of like investigating say the Bali case… and presenting evidence at court… you do not see such variety in disciplines in the one field as you see it in forensic science* (AP1, p26).

c) Forensic scientists need to communicate their scientific knowledge, expertise, and results to a non-scientific audience at the court.

> *One thing that is very unique about forensic science is that practitioners in the field have to communicate their expertise and results in a non-scientific language which is understood by the barristers, judge, and jury* (AP1, p26).

d) Formal education is not always a requirement in forensic science practice.

> *There are some forensic areas where people can be experts through experience like in the areas of firearms and tool marks, where the leading experts are generally police officers that have been doing that job for 15-20 years and are very highly regarded* (AP2, p. 2).

7.2.3.4- Summary of the Third Category of Description

Forensic science, according to the first group participants, possesses more differences than similarities to applied science fields such as medicine and engineering. Forensic science resembles such fields in being a high profile field requiring professional and ethical application of knowledge. Forensic science differs from them in being a new field combining different interest groups, applying science for a legal aim, communicating its scientific results to a non-scientific audience, and abiding by the rules of individual jurisdictions.

The second group participants argued that forensic science is similar to applied science fields in requiring explicitly ethical codes of conduct. On the other hand, forensics differs from such fields in being specific to each individual jurisdiction and in being an ultimate service to the judicial system. Forensics is also different in that it lacks an independent image and caters for non-scientific personnel to work within a scientific environment.

The third group participants argued that forensic science resembles medicine and engineering in being a scientific field which requires high proficiency and ethics. However, forensics is different from these professions because it is impacted by each individual jurisdiction, involves different personnel from different backgrounds and professions, serves the judicial system, requires the non-scientific communication of scientific results, and caters for both formally educated and non-formally educated staff.

7.2.4- Category 4: Forensic Science in Tertiary Education

In this category, the research investigated the perceptions of the various participants on whether or not tertiary forensic science education is a need. The research also examined participants' comments on:

- Report A: The bar chart representing the distribution of forensic science courses amongst various departments/ schools within academia

- Report B: The bar chart representing the distribution of forensic science courses amongst different levels of offer within academia

These 2 reports were generated by the document analysis in chapter 4 (Figure-4a and Figure-4b) and were attached to the research questionnaires which were provided to all participants (Appendix K).

7.2.4.1- Forensic Science in Tertiary Education as Perceived by the First Group Participants

The majority of the first group participants argued against forensic science education starting at an undergraduate level within universities. They argued in the favour of specialised undergraduate science courses (e.g. chemistry or biology). The first group participants defended their argument by making two main points:

a) In forensic science specialisations across different majors are needed. Therefore, a strong science background in each of these majors is required and then the 'forensic flavour' (EP2, p20) can be introduced as it is mainly acquired through experience.

> *Forensic science courses [undergraduate courses] are too many... such an education at university is unnecessary; because in forensic science you need the strong underpinning science but you also need experience and the problem is that you can't get this experience at university; you can only get it on the job... (*EP1, 19).

b) It is unreasonable for year 12 students to restrict their future career opportunities to a field with limited job vacancies, mainly because they are driven by the media:

> *At 17, students do not know what they want to do, and it is unfair to delimit their career opportunities with a focused forensic science degree because at that age they are overtaken with the fantasy of media forensic science; these students want to be forensic scientists as seen on TV shows without knowing what area of science to specialise in, without knowing whether or not they can cope with such a field ...* (EP1, 19).

> *There are very few people working within the profession, so how many people do you want to educate to take on few available positions? At its best you've only got like 50 vacant positions within the whole country on a yearly basis ... universities generate around 500 graduates a year, so what are you going to do about the remaining 450 graduates that aren't going to get jobs in the field that they believe they have been educated for...* (EP4, p21).

These participants argued for postgraduate studies in forensic science, after students have already been equipped with a science degree.

> *There is no need for undergraduate degrees in forensic science; however, there is a place for postgraduate education... There is a very strong case for universities to have a postgraduate diploma in forensic science… when students already hold an undergraduate science degree, they may then do postgraduate studies in forensics where they can pick up the "forensic flavour"... this suggestion is not popular amongst universities, because forensics is a sexy subject, and universities can enrol many students in their courses, not only ordinary students but very good ones...* (EP2, p20).

> *Many of the staff employed here (forensic biology laboratory) have finished an undergraduate science degree and then engaged in a postgraduate research related to forensics... such an approach gives students an exposure to the real world of forensic science, to instruments, techniques, procedures... when students finish their degrees, they'll already know people in forensic labs and they know whether or not they fit in here...* (EP4, p21).

EP3 was the only participant who argued for both undergraduate and postgraduate education in forensic science. EP3 emphasised that starting forensic science early in the academic process- on condition it does not override the science component of the course- would create a forensic sensibility and a broad intellectual appreciation of forensic science and its issues. Such a mind-set and appreciation would otherwise require many years of practice and experience to be acquired.

> *Introducing forensic science early at the undergraduate level helps in shaping a forensic mind-set... it's very important to introduce the forensics: context, complexity and issues right from the start at the same time as you introduce the science without compromising the science bit... it may be hard to do and it's not always possible depending on the university resources, facilities, and links with industry...but the advantage of that is that you create a forensic mind-set within the students, where graduates would then think in the same way as someone who has been in the practice for 10 years....* (EP3, p20).

However, EP3 criticised those education providers who offer forensic science as the 'best selling alternative' for the 'least selling' conventional science courses. (p28). EP3 argues that such courses will sooner or later close down because they are not seriously coordinated and are often run in isolation from the forensic industry stakeholders.

When asked to comment on reports A and B, the first group participants expressed the following comments:

<u>Report A</u>

The 'scatter' of forensic science amongst various departments reflects 'the different sciences that come under the umbrella of forensic science' (EP4, p25). However, the majority of participants favoured that forensic science be administered by a science department. This would help maintain the scientific foundation of the course which is fundamental for the understanding and practice of forensic science. Otherwise, such a foundation may be lost in, for instance, a stand-alone forensic science centre, a criminal justice department, or a multi-departmental course.

> *you want to teach very strong chemistry or biology, a forensic science centre or multi-departmental structure for undergraduate courses means you give people a little bit of this and a little bit of that... they end up being masters of nothing…* (EP2, p22).

Chemistry is a common component in many forensic applications (EP4, p25). However, the highest percentage acquired by chemistry departments (as administering departments of forensic science courses) was attributed by EP3 and EP4 to the crisis conventional science departments- specifically chemistry departments- are experiencing in regard to the continuous decline in students' enrolments.

> *Many universities have just re-labelled their old biology or old chemistry courses as forensic chemistry or forensic biology because students' enrolments in these courses are dropping down…they thought they could get it higher and make more profit by re-labelling it...* (EP4, p25).

> *When you look at the graph you can see there is only 10% in the department of biological science and more than double that amount in the department of chemistry. This reflects the failing demand on chemistry courses within recent school leavers... chemistry courses have been in decline over the past 15 years, but biology departments haven't seen the same effect, because they have things like DNA, biomedical science, biotechnologies, and all these stuff. That's why chemistry departments have been quicker to organise a forensic science degree to fill their quota* (EP3, p23).

<u>Report B</u>

The majority of the first group participants argued against starting forensic science in higher education as early as the undergraduate level because "you don't want to lock people in too early" (EP1, p21). Exceptions to this would be the non-award programs as such programs mainly serve law enforcement agencies and forensic science centres by providing 'further education' to currently employed practitioners and constituting a part of the 'training scheme' designed for novice practitioners (EP4, p25).

In conclusion, the majority of the first group participants argued against undergraduate forensic science courses. However, they argued for postgraduate forensic science education, where students can explore the 'forensic topic' after they have been equipped with strong specialised science degrees during their undergraduate education.

7.2.4.2- Forensic Science in Tertiary Education as Perceived by the Second Group Participants.

All participating field practitioners expressed opinions against introducing forensic science in higher education. They considered offering forensic science courses at universities to be a waste of time, money, effort, and resources for two main reasons:

a) Authentic forensic education starts once individuals are on the job. Moreover, many areas of forensic science may not be taught at universities because such areas are either impractical to be delivered within an academic context, or possess a restricted military nature.

> *I guess teaching firearms and ballistics at universities is nearly impossible, because this field is very military and is restricted to members of the army and police forces… but to learn about firearms you need firearms, you need access to a ballistics and firearms library and laboratory. You wouldn't learn or understand what variable you should be looking for… the degree of variation between two shots from the same firearm unless you are exposed to real shooting scenes… this is not available to students and universities in most jurisdictions... I think they've tried for years and years and the best they can do is basically a physics course and you don't deal with physics on the job… so it's basically wasted information…* (PP1, p20).

b) There is no point enrolling a large number of students in forensic science courses especially when the job opportunities in the field are very limited.

> *My understanding is that there are currently 2600 people enrolled around Australia in a forensic course of some sort, that's just too much; there isn't the demand in industry for it. I don't know what the intake here was last year but if it was over 10 I would be surprised! There is no massive demand here to make a business for these universities by calling a course 'forensic' and getting people interested because it's sexy… Universities are not looking after the interests of the community in terms of gaining employment… It is purely a business arrangement so the universities can derive more money from the community and the government by getting*

> *students in the boring pure science courses after they've inserted the word "forensic" in their titles… there are no jobs at the end so I think it's wrong for the parents who are going to pay for it and wrong for the kids who will be wasting 3-4 years of their life. By these courses they are setting up this big industry for very little opportunity at the end. They're fooling these people*… (PP2, p22).

Advantages for introducing forensic science education in universities were emphasised by laboratory practitioners:

- PP5 argued that the high number of forensic science courses reflects 'an interest in forensic science' and a 'passion' about being a forensic practitioner (PP5, p21).

- PP3 asserted that individuals with forensic science degrees are a 'step ahead' in their 'awareness of forensic science' over those with science degrees once they commence a forensic science job (PP3, P23).

However, PP6 argued that the prior knowledge of the area 'doesn't make a great deal of difference, because the exposure you get once you're in the job is the real education' (p22).

When asked to comment on reports A and B, participants expressed the following comments:

<u>Report A</u>

They expressed the following views in relation to report A:

- Participants expressed opposing views on the highest percentage acquired by chemistry departments as administering houses for forensic science courses. The first view (PP3 and PP6) considered that this high percentage is expected because it reflects the various sub-disciplines and applications in chemistry which are of use in the various forensic science areas. The second view (PP2 and PP4) attributed such high percentage to the fact that chemistry courses suffer from the loss of public interest and drop in students' enrolments. As a result, many of these courses re-labelled themselves as "forensic chemistry courses".

> *I wouldn't be surprised because chemistry is losing bums on seats and losing business; so therefore, let's jazz it up and put the word 'forensic' and then it opens up the doors… that's why it went up* (PP2, p.23).

- The majority of the second group participants were not surprised with the notable percentage of courses administered by public safety departments (5%), as revealed by Report A. This majority argued that such courses mainly aim to educate and recruit police personnel seeking field positions within forensic science.

> *I'm not surprised [public safety department] we are now looking at the entry level for people who are police personnel that are doing it as part of the formalised internal training program for fingerprint examiners, crime scene examiners…* (PP2, p23).

- A number of participants (PP2 and PP6) were against administering forensic science within a stand-alone department. Such departments would create higher expectations of a field with very limited job opportunities:

> *I am against creating an own entity within universities [forensic science departments and centres], I think it's making too big a deal out of it by having their own entity, particularly when you look at the number of jobs that are available for these people…* (PP2, p21).

<u>Report B</u>

Laboratory practitioners emphasised that they prefer to have students first undertake science courses and then if they're interested in forensic science, they might do their honours research on a forensic related topic or pursue postgraduate studies in forensics. This will always give them the option to pursue other career opportunities in case they are unlucky in getting a job within the forensic field.

> *I'd see it working best to do an undergraduate course in one of the main sciences then specialise in the forensic science area… at least by doing a science degree you're getting some sort of knowledge you can even play elsewhere if things don't work out in forensic science... I did a biological science degree and started my forensic education through the honours component of that degree and I thought it gave me a really good sort of background into getting into the job as my research was done in collaboration between the university and here [forensic biology laboratory]… it worked for me basically* … (PP6, p25).

In conclusion, the majority of the second group participants found no advantages in introducing forensic science education in academia, particularly at the undergraduate level.

7.2.4.3- Forensic Science in Tertiary Education as Perceived by the Third Group Participants.

The third group participants expressed divided opinions regarding forensic science tertiary education. The first opinion saw no advantages in offering forensic science education at universities. This is because job opportunities are limited within the field.

> *I don't see any advantages in it, I don't see the advantage in a member of the public who's not going to be acquiring some service in the field… many positions within forensics are restricted to sworn police members*… (AP2, p22).

The second opinion regarded forensic science education at tertiary institutes necessary for 'those forensic areas' which require academic qualifications (AP4, p23). The third opinion argued for 'unrestricted forensic science education' at tertiary institutes (AP1, p14).

Participants, when asked to comment on reports A and B, expressed the following comments:

Report A

Opinions of the third group participants, in regard to report A, varied from:

a) indifference to the identity of the administering department as long as the education is properly done (AP2, p14),

b) preference of a multidisciplinary course because of all the different disciplines incorporated within forensic science (AP1, p14), to

c) preference of a stand-alone entity within academia because forensics is ‘a speciality in its own right’ (AP4, p15).

Report B

When asked to comment on report B, PP2 expressed his appreciation for the existence of the non-award programs because such programs contribute in raising the awareness of police members.

> *I am quite comfortable with the non-award programs which are sufficient for police officers…* (AP2, P14).

Participants AP1 and AP4 argued for a complete forensic science program (Group V: undergraduate and postgraduate courses) within universities, where the undergraduate degree builds the foundation of knowledge and the postgraduate degree provides specialisation in the area of interest.

> *I go for the whole package and I guess the earlier you get into the atmosphere of forensic science the better…* (AP1, P14).

> *I think that it would be important to have both undergraduate and postgraduate courses... the postgraduate studies tend to make you specialise and after you have already acquired your foundation studies at the undergraduate level* (AP4, p15).

In conclusion, the third group participants expressed divided opinions in relation to tertiary forensic science education.

7.2.4.4- Summary of the Fourth Category of Description.

The majority of the first group participants argued against offering forensic science courses at the undergraduate level within tertiary institutes. Such courses may not emphasise the required strong science foundation for the students and may limit their career opportunities. These participants argued for postgraduate studies in forensic science, because these studies take place after the students have already been equipped with a strong science foundation. Such a foundation enables them to seek job opportunities in forensics and other fields.

Perceptions of the second group participants, in the majority, were not in favour of tertiary forensic science education. These perceptions considered such an education a waste of time, effort, and resources. This is because forensic knowledge is mainly acquired through in-service training programs and everyday experience. In addition, the forensic field possesses very limited job opportunities. A number of laboratory practitioners favoured the introduction of forensic education within an honours research thesis or at a postgraduate level.

Perceptions of the third group participants were divided between opinions against forensic science tertiary education and opinions for such education. Opinions against were mainly based on the limited job opportunities within the field, whereas opinions for were mainly based on the need for formal qualifications by a number of forensic areas.

7.3- Inter-categorical Analysis

Subsequent to ‘categorical coding’, where four identity categories of description have been identified, inter-categorical analysis was implemented between the perceptions of the three groups of participants in each of the identity categories. Such analysis took the form of a conversation between the perceptions of each group of participants. This strategy allowed the observation of each categorical identity conception as a summation of the perceptions and experiences of all the three participating groups. It also allowed the generation of inter-categorical identity attributes.

7.3.1- Inter-categorical Analysis across the First Category of Description

In the first category of description, each participating group expressed its views and positions from each listed factor of potential impact/influence on forensic science identity. The position of the participants in each group was presented in a summary tables in section 7.2.1, using numerical values which ranged between -1 and 2, where 2 means the listed factor is the most influencing on forensic identity and -1 means the listed factor has no influence at all.

In this section, the overall position of all the participating groups from each of the listed factors is reported (Table-7h). This was achieved by averaging the values obtained in tables: 7b, 7c, and 7d in regard to each listed factor after it was multiplied by the appropriate loading factor (LF). In other words, values in tables 7b and 7d are multiplied by a LF of 4, as there are 4 participants in each of the first and third participating groups, whilst values in table 7c are multiplied by a LF of 6, as there are 6 participants in the second participating group.

	Media	Judicial System	Police	Politicians	Technology	Forensic Practitioners	Forensic Educators	General Public
Educators (LF4)	**2**	**1.5**	**1.5**	**1.5**	**1.5**	**1.25**	**1.25**	**1.25**
Practitioners (LF6)	**2**	**1.5**	**1.33**	**1**	**1.67**	**0.33**	**-0.33**	**1.17**
Members of Associated Professions (LF4)	**2**	**1.75**	**1.25**	**1.5**	**1**	**0.75**	**0**	**1.25**
Overall Average	**2**	**1.57**	**1.36**	**1.29**	**1.43**	**0.71**	**0.22**	**1.22**

Table-7h

The strength of impact of each of the listed factors on forensic identity is represented in descending order by the following bar-chart (Figure 7b):

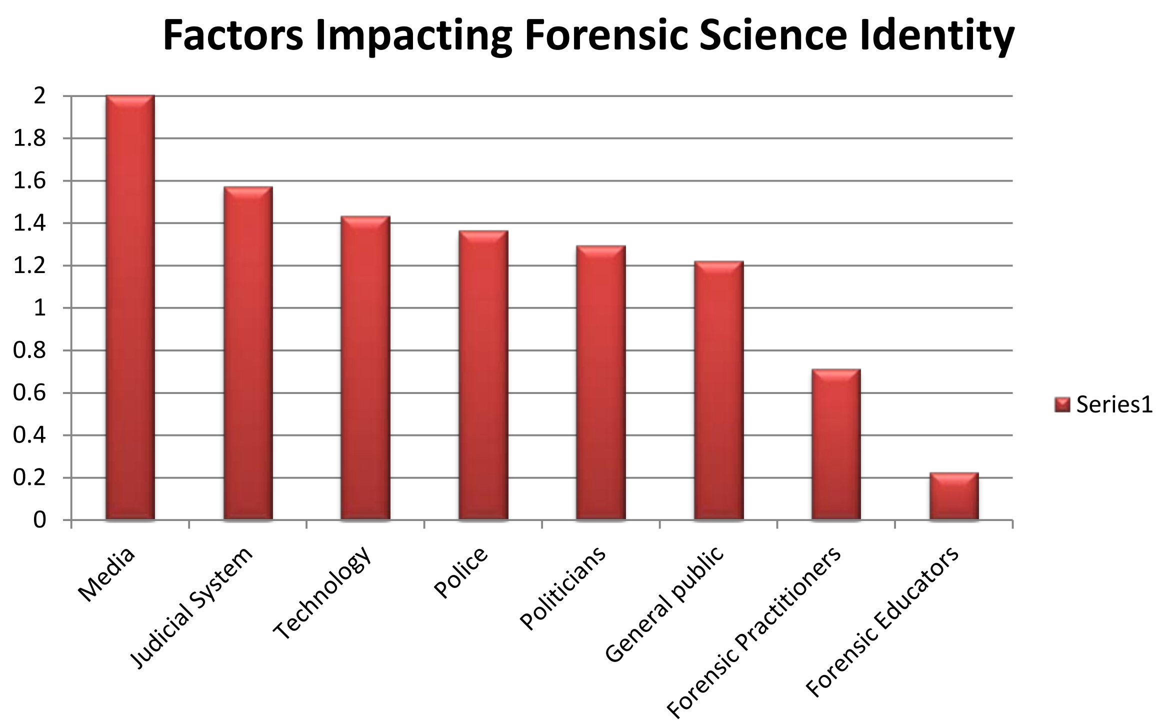


Figure-7b

Media was reported by all participants as being the most influencing factor on forensic science identity. Media drives and shapes public perceptions of forensic science, which are often exaggerated and based on false impressions on what forensic scientists can or cannot do and the time frame it takes to have things done. Amongst those affected are students, police members, and members of the jury. On a more positive side, media scrutiny of forensic science has placed forensic practice under the spotlight. This has contributed to the development of the field and the minimizing of errors and mistakes.

The judicial system has the second major impact on forensic science identity. Ultimately, all forensic investigations, examinations, and analyses are conducted to serve the judicial system. The identity of forensic science as a profession is directly proportional to that of the judicial system it falls within in terms of strength, integrity, and proficiency. Courts have the power to amend forensic practices. Hence, forensic science is practiced differently under different jurisdictions.

Technology has revolutionised forensic science from a field of limited service to a field capable of investigating a variety of cases and testing a variety of exhibits- even the very minute ones. However, this advancement in technology creates more challenges for forensic practitioners to cope with in regard to their education and training.

Police are major stakeholders in forensic science. Their funding of new forensic practices is a result of the importance of forensic science to police forces. Moreover, in many jurisdictions, police members have direct interactions with forensic scientists through crime scene investigation. Police members can direct the criminal investigation of a case into certain pathways and consequently direct the associated forensic investigation. Senior police officers often represent the public face through which forensic achievements and issues are communicated.

Politicians have a strong impact on forensic science in being: a) the policy makers of legislation and acts under which forensic practitioners operate and b) the source for funding. Policies in regard to forensic science and communications with forensic practitioners often pass through the police panels. Hence, politics' impact on forensic science is mainly driven by the police. Likewise, the general public's impact is a major one, but it is driven by the media. The media drives and shapes public perception and awareness of forensic science and forensic related issues.

Forensic practitioners' exposure to the media and general public is restricted. Hence, their impact on forensic identity is restricted to the manner through which they practice forensic science; that is the extent they are ethical, active, and proficient in their every day conduct. Forensic educators' impact on forensic science is limited when compared to other major influential factors (e.g. media and police).

7.3.2- Inter-categorical Analysis across the Second Category of Description

In the second category of description, each group of participants expressed their views in relation to the most appropriate structure under which forensic science may be practiced. Three structures were proposed and discussed: dependent structure, semi-independent structure, and completely independent structure. The position of each participant in each group from the structural identity of forensic science was presented in Tables 7e, 7f, and 7g. In this section, the overall position of all three groups of participants from each of the proposed structures is presented (Table- 7i).

	Dependent Structure	Semi-independent Structure	Completely Independent
Educators	**0**	**3**	**1**
Practitioners	**2**	**2**	**2**
Members of Associated Professions	**0**	**1**	**3**
Total	**— (14%)**	**— (43%)**	**— (43%)**

Table-7i

Table-7i shows that the majority of the participants (57%) emphasised the need for forensic science to run under one of the forms under police authority, despite whether such an authority is absolute (14%) or limited (43%) . Nevertheless, there is a strong case and argument (43%) for running forensic science under structures completely independent from the police. The only consensus amongst all participants- despite their preferences- was on the strong links which always need to be maintained between forensic science and the police.

7.3.3- Inter-categorical Analysis across the Third Category of Description

In the third category of description, each group of participants expressed their views and opinions in comparing forensic science to applied science fields such as engineering and medicine. A summary of the perceptions of each group of participants in regard to reported similarities and differences between forensics and applied science fields is detailed in Table-7j.

	Similarities	Differences
1st Group Participants	▪ Requires good knowledge, and the application of such knowledge in a proficient and ethical way ▪ High profile identity	▪ Relatively new area/field ▪ A practice fragmented between laboratory and field work ▪ An interest group rather than a profession ▪ Communicate scientific results to non-scientific audience ▪ Using science as a tool not an object of study ▪ Impacted by individual jurisdictions
2nd Group Participants	▪ The use and application of scientific knowledge in mainly every task. ▪ High ethical requirement	▪ Specific to individual jurisdictions ▪ Unique nature ▪ Serves the judicial system ▪ Lacks the profile of the independent stand-alone field ▪ Caters to scientific and non-scientific personnel
3rd Group Participants	▪ Requires knowledge, proficiency, and ethics ▪ Mistakes are costly	▪ Characteristic of each individual jurisdiction ▪ Different personnel from different backgrounds and professions ▪ Serves the judicial system ▪ Communicate their knowledge and expertise to a non-scientific audience ▪ Formal education is not always a prerequisite

Table-7j

Inter-categorical analysis revealed that the majority of participants argued that forensic science is:

a) Similar to fields of applied science in requiring both high proficiency in the use and application of scientific knowledge, and high ethical commitment and conduct.

b) Different from such fields in being a field:
   - Specific to individual jurisdictions
   - Ultimately serving the judicial system, where science is used as a tool to serve a legal cause
   - Unable to represent itself as a profession but rather as a combination of different interest groups serving the one aim
   - Suffering fragmentation between fieldwork and laboratory work
   - Communicating its expertise to a non-scientific audience
   - Possessing a dominant policing image/identity

In summary, forensic science is different from rather than similar to counterpart applied science fields such engineering and medicine.

7.3.4- Inter-categorical Analysis across the Fourth Category of Description

In the fourth category of description, all interviewees expressed their perceptions on whether or not forensic science courses need to be offered in tertiary education. They also commented on the current status of forensic science courses as revealed by the two statistical reports: A & B. A summary of each group's perceptions and comments about forensic science education is presented in the following table (Table-7k).

	First Group Participants	Second Group Participants	Third Group Participants
Overall Position	- Majority against undergraduate tertiary forensic science education, but in favour of postgraduate forensic science education.	- Majority finds more disadvantages in undergraduate forensic science courses than advantages.	Equally divided opinions
Argument Against	- a strong science background is primarily required at the undergraduate level, after which the forensic flavour is acquired mainly through experience - unreasonable to lock the career prospective for year 12 students within a field of limited career opportunities	- Practical forensic education starts once individuals are on the job - Many areas of forensics may not be delivered at universities. - Limited career opportunities	- Job opportunities are very limited in the field and - Forensic knowledge is often acquired on the job.
Arguments For	Create a forensic mind-set and a broad intellectual appreciation of forensic science and its issues.	- shows an interest in forensic science -Provide appreciation and awareness for graduates of the type of work awaiting them	Tertiary forensic education is the primary step in gaining forensic appreciation and knowledge
Report A	- Forensics to be administered by science departments - Many chemistry courses are taking advantage of the word 'forensic'	- Against administering forensics by a stand-alone department - divided opinions towards the highest percentage of forensic science courses administered by chemistry departments	Divided opinions in regard to the nature of the administering department
Report B	Majority favours Postgraduate studies in forensic science	Laboratory practitioners favour forensic education starting at postgraduate level	Divided opinions

Table-7k

The majority of participants (9 of 14) argued against tertiary forensic science education at the undergraduate level. This argument was supported by a number of justifications. First, a strong science foundation is required for individuals seeking employment in forensics. Second, delivering forensic science at universities remains theoretical rather than practical, because many areas of forensic science require a crime scene context to be acquired. In addition, a number of forensic areas are of a military nature, i.e. they involve weapons and explosives. Hence, these areas are restricted to sworn police members. Third, forensic science is a field of limited career opportunities. Hence, undergraduate forensic courses which enrol large numbers of students potentially limit their career opportunities and create disappointment for the majority of these students who will not be employed in the forensic field.

Few participants amongst all three groups argued for an early commencement of forensic science courses in academia, i.e. at the bachelor level. Such early commencement of forensic science education contributes to the creation of a forensic sensibility for forensic science issues, processes, and challenges for the students.

The majority of the participants appreciated the notable percentage (18%) of the non-award forensic science programs (Report B), specifically those administered by public safety departments (Report A). Participants argued that these courses mainly serve law enforcement agencies and forensic science centres by: a) providing ‘further education’ to currently employed practitioners and b) constituting a part of the ‘training scheme’ designed for police personnel aiming to join field positions within forensic science.

The majority of participants criticised the high distribution (23%) of forensic science courses amongst chemistry departments as revealed by Report A. These participants attributed such high percentage to the crisis many of chemistry departments suffer from in promoting themselves and attracting enrolments. Many of the chemistry courses were threatened by closure over the past years due to the loss of public interest in traditional science courses. Therefore, many of these courses took advantage of the adjective ‘forensic’ in their titles to increase enrolments and attract funding.

The participating laboratory practitioners and the majority of the participating educators argued that there is a strong case for forensic science education to be offered at a postgraduate level. Students, at such a level, have already been equipped with a specialised science foundation. Hence, they have a variety of career opportunities, amongst which are positions within forensics. Moreover, many students who conduct postgraduate research in a forensic or forensic-related topic are given the opportunity to carry out their research in collaboration with forensic laboratories. Such research experiences expose students to the forensic workplace, techniques, and instruments on the one hand, and facilitate contacts with forensic personnel who might become their potential employers on the other.

7.3.5- Summary of the Inter-categorical Conceptual Attributes across the Four Categories of Description

The inter-categorical conceptual attributes arising from the inter-categorical analysis across the four categories of description are summarised in the Table-7L.

	Summary of the Inter-categorical Identity Conceptual Attributes
1st Category of Description	An explicit quality of forensic science identity is the multiplicity of factors which influences such identity, the most major of which are the media, judicial system, technology, and police.
2nd Category of Description	Forensic science can never lose its strong links with the police regardless of the organisational structure under which it operates.
3rd Category of Description	Forensic science applies scientific knowledge similar to a number of applied sciences; however, forensic science is very different to other applied science fields.
4th Category of Description	Offering forensic science courses in tertiary education, specifically undergraduate courses, raises concerns, dilemmas, and questions much more than offering opportunities within the forensic science field.

Table-7L

7.4- Towards a Forensic Science Identity: A Cross- Categorical Synthesis

Following inter-categorical analysis, cross-category synthesis amongst the identified inter-categorical attributes was conducted to identify:

a) themes relating to the nature of forensic science identity,

b) a general set of exemplars reflecting forensic science identity, and

c) implications for forensic science education which respond to the identity of forensic science and emphasise the identified exemplars.

Cross-comparison synthesis was carried out as pedagogical discourse (Bernstein, 2000) between at least two inter-categorical identity attributes emerging from different categories of description, where such attributes were re-contextualised and re-conceptualised into identity themes. Such an approach allowed the identification of five identity themes.

The exemplification of each of the five themes generated a set of five identity exemplars. Finally, the research identified implications for forensic science education which respond to the nature of forensic science identity and emphasise the identified identity exemplars.

Similar to the approach adopted in previous chapters, the research referring to the first, second, third, and fourth categories of description by IC1, IC2, IC3, and IC4 respectively.

7.4.1- The Nature of Forensic Science from an Identity Perspective

Similar to the approach adopted in chapters 5 and 6, themes that meet specified criteria were reported in this chapter. The criteria for reporting the themes are as follows:

1. The theme is not specific to any one perception of an individual participant or an individual group of participants.
2. The theme is generated following pedagogic discourse between at least two inter-categorical conceptual attributes emerging from different categories of description.
3. The theme is significant with respect to the major research question and supplementary research questions.

<u>Theme1: The Unique Nature of Forensic Science</u>

Forensic science possesses a unique nature. The uniqueness of forensic science was identified following discourse across attributes of IC1, IC2, and IC3:

- Forensic science is explicit in the multiplicity of factors which influence its identity (IC1).
- Forensic science possesses an uneasy and complex relation with the police. Whilst forensic practitioners need to bring about good, impartial, and proficient science practices, they cannot be totally removed or isolated from police practices which, in this case, aim to bring about prosecution (IC2).
- The differences existing between forensic science and similar applied science fields, which exceed any resemblance between forensic science and those fields, contribute to the uniqueness of the forensic science field (IC3).

These factors make the identity of forensic science unique in comparison to other fields of practice or professions.

<u>Theme 2: Police Ownership of Forensic Science</u>

IC2 revealed that the majority of the participants (57%) emphasised the need for forensic science to run under one of the police structures: complete dependent structure (14%) or semi-independent structure (43%). A minority of participants (43%) argued for complete independence of forensic science from police departments. However, these participants, along with all the other participants, stressed that forensic science can never lose its strong link with the police (IC2). On the other hand, the majority of all participants emphasised the major impact police have on forensic science identity (IC1). The majority of participants regarded police as major stakeholders in forensic science. Therefore, police possess ownership in forensic science. They are natural partners with forensic practitioners in serving the judicial system.

Theme 3: Judiciary Ownership in Forensic Science

Other owners/stakeholders in forensic science are the judiciary. One of the unique features which differentiate forensics from similar applied fields of science (e.g. medicine and engineering) is that the ultimate context of any forensic work is judicial, where forensic practitioners ultimately present their evidence, analyses, and opinions to a court of law (IC3). This context is one of the major influences on forensic science identity, where the judiciary has the power to change forensic practices in a manner that is suitable for courts (IC1).

Theme 4: The Stereotyped Image of Forensic Science

The media has created an identity of perfectionism and heroism for forensic practitioners. Members of the public, amongst whom are police officers, students, and members of the jury, often create an exaggerated and ideal image of forensic science and forensic practitioners (IC1). They often expect forensic practitioners to be able to solve any crime and answer any crime-related questions in a speedy manner. This stereotyped image has contributed to the dramatic expansion of forensic science education and increase in forensic science courses offered worldwide (IC4). Such an expansion and increase occurred regardless of the market capacity and the limited career opportunities in forensic science.

Theme 5: Undeveloped Professional Status

Forensic science has not developed as a profession. This was suggested following a discourse across attributes of IC1, IC2 and IC3:

- External factors (e.g. media, police and judiciary) are the major contributors in shaping forensic practice, whilst internally, forensic practitioners' contribution is minor (IC1).
- Forensic science cannot liberate itself from police authority and management. Hence forensics is unlikely to emerge as a stand-alone practice entity (IC2).
- Forensic science incorporates different disciplines, expertise, and backgrounds. The jobs within the forensic field are varied; hence, the prerequisites to enter in these jobs vary as well (IC3).
- Forensic practice is specific to each individual jurisdiction and assessed by non-scientific personnel: judge, jury, defence, and prosecution (IC3).

Forensic practitioners are unable to represent themselves as one body or profession and they are unable to promote the independence of their practice from the influences of the police and judiciary. Hence, forensic science remains a profession with an undeveloped status.

In summary, this section identified 5 themes which relate to the nature of forensic science from an identity perspective. Forensic science is a unique field, in which both police and judiciary have ownership. Forensics possesses a stereotyped image formed by the media and public perceptions. The forensic profession is an undeveloped one, and it is rather a combination of various professions under the one "forensic" heading.

7.4.2- The General Set of Identity Exemplars

The research identified a general set of five identity exemplars. These exemplars may be used amongst:

- Forensic science educators and practitioners to identify the general status, image, and profile of forensic science in comparison with similar applied science fields.
- Forensic policy makers and members of associated professions to gain insights into the identity of forensic science.

The five identity exemplars and the respective theme which they illustrate are presented in the following table (Table-7m).

Identified Exemplar	Portraying Theme
Exemplar 1: The complex identity of forensic science	Theme 1
Exemplar 2: The policing context required in forensic science	Theme 2
Exemplar 3: The legal context required in forensic science	Theme 3
Exemplar 4: The high-risk ethical and professional environment of forensic science	Theme 4
Exemplar 5: The field of interest groups	Theme 5

Table-7m

Exemplar 1

The unique nature of forensic science (theme 1) is the result of the complex identity forensic science possesses. Complexity emerges from:

- The complex relation which exists between police officers and forensic scientists emerges from differences in the mindset and role of each party. Police officers possess a military mindset and their role in criminal investigation is to bring about prosecution. On the other hand, forensic scientists are first and foremost scientists whose role is to bring about convincing scientific analyses of the collected evidence. Given that both parties always work in cooperation and that police departments often manage, fund, and direct forensic science practice, it might be hard to keep police removed from the scientific observations and analyses of forensic practitioners:

  Some police think, because we are paid by the police department, that we have to answer according to what the investigators wants, in some cases, the only reason he sent the evidence is because he thinks that this occurred and he wants something official to say and he'll quite be

> *shocked, if you say " no it's wrong, it's not the way it has gone"* (PP4, p30).

- The external factors (e.g. media, judicial system, politicians, and the general public) which constitute the majority of factors influencing forensic science identity as revealed by Table-7h in IC1. This makes forensic science a field mainly influenced and shaped by external stakeholders rather than internal stakeholders (e.g. forensic practitioners and forensic educators).

- The wide range of disciplines, backgrounds, and professions which are incorporated within its landscape differ from any other field or profession:

  > *From my perception forensic science is a very complex and wide range field which incorporates too many disciplines, professions, and expertises in order to assist in the administration of justice… You do not see such variety in disciplines in the one field as you see it in forensic science* (AP2, p19).

Hence forensic science identity is complex. Such complexity makes forensic science an 'unusual field' requiring 'unusual work' (PP6, p30).

<u>Exemplar 2</u>

Police are natural partners of forensic practitioners. Hence forensic science practice, despite its organisational model or structure, can never escape a strong partnership with the police for a number of reasons:

- Police are major contributors in the policies, codes, practices, resources, and finance of the forensic field (IC1).
- Police will always be the first to call when a crime or an offence takes place. They will be the party responsible for securing the crime scene. Detectives, who are originally sworn police members, are in charge of the criminal investigation process: crime investigation, interrogation, and arresting suspects. Police often bring the evidence to the forensic science centres and take it back to courts (Inman and Rudin, 2001).
- Sworn police officers are often in charge of processing those forensic areas of:

- unique forensic nature such as crime scene investigation and fingerprinting (e.g. PP2 is a sergeant in the police forces and a senior crime scene examiner) and
- explicit military nature such as firearms and explosives (e.g. PP1 is a sworn police officer and a firearms and ballistics expert).

This partnership requires forensic practitioners to adapt to a police environment which ‘bring about the context and broader understanding of the entire criminal jurisdiction processes and their implications... and bring about the pluses and the minuses’ in the field (EP2, p14).Therefore, the scientific work of forensic practitioners needs to integrate with a policing context which surrounds, directs, and facilitate such work.

Exemplar 3

Forensics is a science pertaining to law. It is science ‘applied in context for the courts’ (EP2, p14). Hence, scientific work and analyses will not be termed as ‘forensic’ if not applied within a legal context. Unlike many scientific fields, the object of study in forensic science is science itself, but the context is legal. Forensics uses science not for the sake of science but for legal purposes.

> *Forensics is pertaining to matters of law, we give evidence to court, so everything that we do day to day, is collected and examined and recorded and commented on in a way that is legally acceptable for the court and we present that evidence in court. So every moment of my day in forensics is related to the legal system*… (PP2, p12).

The ultimate evaluation of any forensic work is conducted from a legal and not scientific perspective: whether or not presented evidence is admissible by the court, understood by the judge, jury, and legal practitioners (non-scientific recipients), etc.

Exemplar 4

The Media have created an image of forensic practitioners as being ethical seekers of truths and justice (Theme 4). This image might seem only a stereotyped one from an outsider viewpoint. However, from an internal perspective, forensic practitioners hold a high moral responsibility, duty of care, and duty of professionalism towards the justice system they serve.

Forensic science resembles other applied science fields (e.g. medicine) in their requirement for high ethical conduct (IC3). Forensic practitioners have a peculiar responsibility towards the justice system they serve. They have the capacity to influence the outcome of many cases and to change verdicts from innocence to guilt and vice versa. In other words, unethical or irresponsible conduct of forensic practitioners can cause justice miscarriage.

> *Forensic scientists have a peculiar responsibility because they do have the capacity to influence cases which frequently involve the risks of the liberty of the subject… where persons facing imprisonment in terms of 20 years onwards… all the integrity and the skills which they bring to their work can be absolutely crucial to the outcome of the case and so in terms of outcomes they probably have the greatest capacity to influence the outcome of criminal cases… I think it is terribly important for them to be ethical* (AP4, p11).

Forensic science image and reputation derive from both the impartiality and ethics of the forensic practitioners (IC1). Forensic science often enjoys better recognition in judicial systems than other fields involved in justice administration (e.g. psychology). Factors such as unethical conduct, partiality, and bias ruin the credibility and reputation of any expert witness and negatively impact the field of the witness:

> *I've certainly dealt with cases where experts called against my case appear to have been prepared to express the opinion that they thought was going to suit the cause of the side by whom they were hired. In such cases these practitioners become "guns to hire" … I've seen this particularly in cases involving claims for compensation, personal injury, etc* (AP4, p10).

Margins of human error are recognized in most fields even in medical practice. However, forensic science does not enjoy any exemption for errors and mistakes because media scrutiny will exaggerate the one mistake and ignore thousands of accomplishments by the field. This imposes a high duty of care and professionalism on forensic practitioners towards every conducted activity and performed task.

> *If we start making mistakes because one of your colleagues didn't follow certain rules, didn't apply certain knowledge in the right way, or misbehaved, then that will negatively back down our image. You can do things well thousands of times but if one does it wrong one time the next thousand will mean nothing. So you've always got to do things right… we always need to maintain integrity and high ethical conducts in our practice* (EP4, p29).

Forensic practitioners operate in a high-risk environment which requires explicit ethical commitment, duty of care, and professionalism. They always need to possess a high moral responsibility towards ensuring that evidence is always collected, examined, and analysed in a proficient way and within minimal margins of error. They are also responsible for presenting evidence to courts in an impartial manner disregarding the calling side: prosecution or defence. Forensic practitioners always need to bear in mind the costly consequences of any committed mistake or misconduct.

<u>Exemplar 5</u>

The undefined professional status of forensic science (Theme 5) makes forensic science a field of interest groups rather than a defined profession. There are several reasons which hinder the development of forensic science as a defined profession. These reasons are:

- The inclusion of various professions (e.g. medical practitioners, chemists, biologists, crime scene examiners, vehicle examiners, etc) with various backgrounds and mentalities relevant to their original disciplines rather than to forensic science. This makes those professions so different and only similar in their common interest to serve the justice system:

  > *The justice system invites all those different expertises and professions coming from different backgrounds… they sometimes have nothing in common but to serve the justice system* (AP3, p22).

- Judiciary ownership in forensic science (Theme 3) makes forensic science more of a subsidiary field of the legal profession, rather than a stand-alone profession. The judicial system controls forensic science to an extent that PP2 clearly emphasises that forensic practitioners 'work to the clock of the court' (p26). Moreover, forensic science is practised differently under different jurisdictions amongst the different countries and sometimes amongst the different states of the same country. This has been emphasised by a number of participants. For instance, EP4 points out the differences in the way forensic science is practiced between two Australian States: Victoria and New South Wales.

> *Victoria's crime scene officers are police officers, whereas NSW crime scene officers are civilians who are science graduates… The NSW officers are more scientific oriented. They are not only required to collect samples [field work] but also they are able to create profiles [laboratory work], whilst Victorian field officers are more military minded and cannot proceed to laboratory work* (EP4, p14).

- Police ownership in forensic science (Theme 2) via a complex relationship with forensic science practitioners hinders the formation of an independent identity for forensic science. Forensic scientists are expected to possess a pure scientific mentality independent of police mentality, practices, and role in bringing about prosecution. Such an expectation may not be totally achievable in practical terms as forensic scientists are operating within police contexts and in partnership with them, where the police are often the dominant party in such a relationship.

These reasons contribute to the undefined status of forensic science as a profession. This leaves forensic science as a field of interest group(s) rather than being a profession in its own right. In this respect, EP3 argues:

> *Forensic science is a new field. It might come one day to become a stand-alone profession with a standalone identity, but I don't think it will come in the near future... In the future, with more science migrating into field work, I expect that all the distinction between field and lab won't exist anymore. This will homogenise forensic science practice a bit. Nevertheless, there will always be some forensic specialities which are very marginal, for example, forensic entomology. Therefore, there will always be some peripheral forensic professions* (EP3, p12).

In summary, the research presented a general set of 5 exemplars which reflect the nature of forensic science identity. Through these exemplars, forensic science is seen to possess a complex identity, to require a legal context and a policing context for operation, and to demand high ethical and professional commitments. Despite all its unique feature, forensic science is not a stand-alone defined profession, but merely a field of interest groups.

7.4.3- Education which Responds to the Nature of Forensic Science Identity and Emphasises the Identified Identity Exemplars

In an approach similar to that adopted in chapters 5 and 6, the research examines the perceptions and expectations held by the various forensic social groups of issues relating to forensic science identity. The research then emphasises the complexities which have arisen in response to the nature of forensic science identity.

Forensic social groups

Throughout chapter 7, each group of participants held opinions and perceptions about forensic science identity which complemented in certain instances and conflicted in others. Whilst their perceptions mainly complemented in the first and third categories of description, the three participating groups expressed clashing opinions in relation to a number of forensic identity issues. For example, in the second category of description, the majority of the participating educators (3 out of 4) argued for a semi-independent structure for forensic science to operate within. On the other hand, the majority of the participating members of associated professions (3 out of 4) argued for a completely independent structure for forensic science.

Clashes in opinions clearly existed within the second group of participants, where the majority of field practitioners (2 out of 3) favoured a dependent structure for forensic science, whereas, the majority of laboratory practitioners (2 out of 3) favoured a completely independent structure. The remarkable note in this regard is that field practitioners, who are sworn police officers, strongly defended their perceptions by stressing the potential threat of losing bonds and links with the police if removed from under police departments. On the other hand, laboratory practitioners, who are civilians, strongly defended independence from police departments by the need to maintain a scientific environment and mindset under which they need to operate. This particular example suggested that perceptions and opinions of the second group participants were informed by their backgrounds and mindset: military versus scientific.

The three participating groups in this research are representative of the social groups which are related to forensic science: forensic science educators (EP1, EP2, EP3, and EP4), forensic field practitioners (PP1, PP2, and PP4), forensic laboratory practitioners (PP3, PP5, and PP6), and members of associated professions (AP1, AP2, AP3, and AP4). This connects with Bernstein's notion of social groups and how such groups express their interests and perceptions in decisions related to their field (2000). This notion will be further explored in chapter 8.

Complex Education Approach

Forensic science is seen as a complex field (exemplar 1) with unique and exceptional nature (theme1). Hence, any educational approach in forensic science is expected to:

- Emphasise the complex nature of forensic science identity (exemplar 1)
- Cater to the policing context essential for forensic science (exemplar 2)
- Cater to the legal context required for forensic science (exemplar 3)
- Promote high ethical and professional commitment for work in a high-risk environment (exemplar 4), and
- Recognise the undeveloped professional status of forensic science (exemplar 5) and the variety of stakeholder in forensic science.

The education setting needed to emphasise all the above points is problematic. This is because such a setting needs to go beyond the university environment to a number of environments where access is limited or restricted such as police departments, coroner's office, courts, forensic science centres, and forensic science laboratories.

Another challenge which faces forensic science education is the dramatic increase in the number of forensic courses and enrolments in such courses. This increase is driven by external factors (media and public interest) regardless of the internal stakeholders of the field (IC1). Hence, forensic science education is expanding in academia. Such an expansion is not in proportion with the size of the forensic industry and market capacity, where the forensic science vacancies available each year are limited in comparison to the accumulating number of forensic science graduates (IC4). This raises a question about the authenticity of such forensic science courses offered in academia. This question will be further explored in chapter 8.

Forensic science education also faces a challenge in the number of stakeholders in forensic science and the clashing interests that might emerge from those stakeholders. This raises a question about the education decisions which need to be taken by the course coordinators of forensic science courses. These decisions need to balance between the external stakeholders' interests, the internal stakeholders' requirements, and the actual content required to reflect forensic science identity. These decisions will be further discussed and explored in Chapter 9 along with the findings from Chapters 4, 5, and 6.

In summary, the research examined the various perceptions of the various participating groups in regards to forensic identity conception. These perceptions are important in discussions related to forensic science education. In addition, forensic science education faces a number of challenges in emphasising the forensic identity exemplars. Challenges arise in attempting to manage the academic boom in forensic science courses (enrolments) versus limited forensic career opportunities, and in balancing between the various interests and influences of various forensic stakeholders in a forensic course content.

7.5- Chapter Summary

This chapter was organised four sections. The first section, introduced its aim, structure, and relation with the preceding two chapters (chapters 5 & 6). This chapter is a qualitative analysis of forensic science identity as being one of the determining factors of forensic science education: knowledge, practice, and identity.

The second section presented four categories of description relating to forensic science identity. The stance of each of the participating groups from each identity category was addressed in an independent subsection.

The third section conducted inter-categorical analysis within each identity category. Such analysis took the form of a conversation between the perceptions of each group of participants in regard to each category of description. Such conversation allowed the observation of each identity category as the summation of the perceptions of the three groups of participants and the generation of inter-categorical identity attributes.

The fourth section reported five cross-categorical themes relating to the nature of forensic science identity. Further exemplification of the themes created a general set of five identity exemplars and generated implications for forensic science education from a forensic identity perspective.

As a whole, this chapter presented participants' conceptions of forensic science identity and an analysis of these conceptions. The following chapter (Chapter 8) is the discussion chapter in relation to nature of forensic science. This discussion will take the form of a pedagogical discourse across the findings of Chapters 4, 5, 6, and 7.

Chapter 8: Discussions Related to the Nature of Forensic Science

8.1- Introduction

This chapter is the first of two discussion chapters: chapter 8 and chapter 9. Chapter 8 comprises discussions about the nature of forensic science knowledge, practice, and identity, from which findings about the ontology and epistemology of forensic science emerge. Chapter 9 will comprise discussions about the nature of forensic science education which responds to the identified ontology and epistemology of forensic science. Recommendations from such discussions about forensic science education will be concluded in chapter 9.

The discussions in Chapter 8 are conducted as a pedagogical discourse (Bernstein, 2000) across the identified themes and exemplars emerging from the analysis of the semi-structured interviews (chapters 5, 6, and 7) on the one hand, and between these themes and exemplars and those emerging from the document analysis (chapter 4) on the other hand. Such discourse will re-contextualise and re-conceptualise the identified themes, where they are transformed from their original sites (chapters 4, 5, 6, and 7) into a new conceptual and contextual site (chapter 8). This transformation will generate findings in relation to the nature of forensic science knowledge, practice, and identity. These findings will create insights into forensic science education: curriculum and pedagogy. These findings and insights answer the major and supplementary research questions. Prior to the discussion, the findings of each of the document analysis and analyses of the semi-structured interviews are summarised in the following section.

8.2- Summary of Data Analysis

Data was generated from a two-phase research methodology: document analysis and semi-structured interviews. Analysis of the data emerging from document analysis was presented in chapter 4. Analysis of the data emerging from semi-structured interviews was distributed over three chapters:

- Chapter 5 comprised analysis of the interview data related to conceptions of forensic science knowledge.

- Chapter 6 involved analyses of the interview data related to conceptions of forensic science practice.
- Chapter 7 comprised analysis of the interview data related to conceptions of forensic science identity.

For enhancing readability and ease of referring to the identified themes/exemplars in each of chapters 4, 5, 6, and 7, the research adopted codes symbolising each of these themes/exemplars. The coding symbols are as follows:

- Themes identified in chapter 4 (document analysis) were symbolised with a code which starts with the three letters D, A, and T followed by a digit (#= 1, 2, 3 ...), where DA stands for document analysis and T# refers to theme number #. For instance, DAT1 stands for theme 1 identified from document analysis.

- Themes and exemplars identified in chapter 5 (conceptions of forensic science knowledge) were symbolised with a code which starts with the three letters K, n, and T representing the identified knowledge themes and the letters K, n, and E representing the identified knowledge exemplars. These codes are followed by a digit (#) referring to a particular theme or exemplar. For example, KnT2 stands for knowledge theme 2, whereas KnE2 stands for knowledge exemplar 2.

- Themes and exemplars identified in chapter 6 (conceptions of forensic science practice) were symbolised with a code which starts with the three letters P, r, and T representing the identified practice themes and the letters P, r, and E representing the identified practice exemplars. These codes are followed by a digit (#) referring to a particular theme or exemplar (e.g. PrT3 or PrE1).

- Themes and exemplars identified in chapter 7 (conceptions of forensic science identity) were symbolised with a code which starts with the three letters I, d, and T representing the identified identity themes and the letters I, d, and E representing the identified identity exemplars. These codes were followed by a digit (#) referring to a particular theme or exemplar (e.g. IdT1 or IdE3).

8.2.1- Summary of the findings of chapter 4: Document Analysis

Chapter 4 reported a document analysis on the curricula of 190 listed forensic science programs offered worldwide in order to generate an understanding of the current academic status of forensic science, an educational field about which little has been known or published. Document analysis was informed by the results of the typology of 16 forensic science courses which was presented in chapter 1. In addition to generating understanding of the current status of forensic science education and insights into forensic science knowledge, practice, and identity, chapter 4 identified grey areas which were investigated and clarified by the second phase of the research methodology. A summary of the identified themes from chapter 4 is presented in Table-8a.

Summary of the Findings of Chapter 4	
Theme 1 (DAT1)	Forensic science is a high profile field which enjoys media focus. As a result, forensic science education has dramatically expanded within academia.
Theme 2 (DAT2)	Forensic science is a segmented field across various disciplines and professions. Such segmentation is reflected in the curricular organisation of forensic science courses.
Theme 3 (DAT3)	Forensic science education suffers uncertainty in relation to the level of academic offer and the identity of the administering department.
Theme 4 (DAT4)	Forensic science knowledge comprises a science component and a practical component. Whilst the science component can be delivered within a university setting, the practical component requires a practice-based setting.
Theme 5 (DAT5)	There is differentiation between forensic field practice and laboratory practice in terms of education, job prerequisites, and identity of practitioners.
Theme 6 (DAT6)	The nature of practice in forensic science is affected by the individual legislation and regulatory schemes characteristic of each individual jurisdiction.
Theme 7 (DAT7)	Typically, forensic science practice is an explicit public practice mainly housed under the police umbrella.
Theme 8 (DAT8)	The extent to which forensic science practitioners contribute in the delivery of forensic science courses at universities seems to be directly proportional to the extent of socialisation between the university itself and the relevant law enforcement agencies.

Table-8a

8.2.2- Summary of the Findings of Chapter 5: Conceptions of Forensic Science Knowledge

Chapter 5 reported conceptions of forensic science knowledge as revealed by the data collected from the conducted interviews with the three groups of participants (forensic science educators, forensic science practitioners, and members of associated professions). Chapter 5 presented four forensic knowledge themes and a consequent four forensic knowledge exemplars. A summary of the identified knowledge themes and exemplars is presented in Table-8b.

Summary of the Findings of Chapter 5 (Forensic Science Knowledge)	
Theme 1 (KnT1): The nature of forensic science knowledge is of a specialised science nature- to a greater extent in laboratory practices and applications.	**Exemplar 1 (KnE1):** The scientific component of forensic knowledge
Theme 2 (KnT2): Forensic science knowledge is vocational in nature- to a greater extent in field practices and applications.	**Exemplar 2 (KnE2):** The vocational component of forensic knowledge
Theme 3 (KnT3): Forensic science knowledge possesses a legal nature.	**Exemplar 3 (KnE3):** The legal component of forensic knowledge
Theme 4 (KnT4): Essential forensic science competencies mainly comprise critical thinking and communication skills.	**Exemplar 4 (KnE4):** Essential Forensic Capabilities

Table-8b

In addition to knowledge themes and exemplars, Chapter 5 discussed implications for forensic science education which respond to these themes and exemplars. The identification of various forensic social groups, that hold various opinions about forensic science knowledge representing their standpoints and backgrounds, was first emphasised in chapter 5 and then re-emphasised in chapters 6 and 7 from practice and identity perspectives. This chapter also discussed the challenges which face forensic science education in emphasising forensic science knowledge.

8.2.3- Summary of the Findings of Chapter 6: Conceptions of Forensic Science Practice

Chapter 6 reported conceptions of forensic science practice as revealed by the data collected from the conducted interviews. This Chapter presented four forensic practice themes and a consequent four forensic practice exemplars. A summary of the identified practice themes and exemplars is presented in Table-8c.

Summary of the Findings of Chapter 6 (Forensic Science Practice)	
Theme 1 (PrT1): Crime scene processing represents the foundation of forensic science practice.	**Exemplar 1 (PrE1):** Forensic science sensibility
Theme 2 (PrT2): Forensic science practice is of a complex nature: unanticipated nature of the crime scene, contribution of personnel of different backgrounds in crime scene processing, and the complexity in communicating scientific and technical terms to non-scientific and non-technical recipients.	**Exemplar 2 (PrE2):** The complexities of forensic science practice
Theme 3 (PrT3): The critical nature of forensic science practice which emerges in response to the complex nature of such practice.	**Exemplar 3 (PrE3):** The requirement for a critical application of forensic science.
Theme 4 (PrT4): The nature of forensic science practice is segmented between field and laboratory practitioners.	**Exemplar 4 (PrE4):** Segmented forensic science communities of practice

Table-8c

Chapter 6 also discussed implications for forensic science education which respond to the identified practice themes and exemplars. The notion of the existence of various social groups within forensic science was re-emphasised in this chapter but from a practice perspective. This chapter also presented the complexities which face forensic science education in responding to the identified exemplars.

8.2.4- Summary of the Findings of Chapter 7: Conceptions of Forensic Science Identity

Chapter 7 reported conceptions of forensic science identity as revealed by the interview data collected. This Chapter presented five forensic identity themes and a consequent five forensic identity exemplars. A summary of the identified identity themes and exemplars is presented in Table-8d.

Summary of the Findings of Chapter 7 (Forensic Science Identity)	
Theme 1 (IdT1): Forensic science is of a unique identity given the multiplicity of factors which shape its nature, the uneasy and complex structural relationship which exists between forensic science centres and police departments, and the many features which differentiates forensic science from similar applied science fields.	**Exemplar 1 (IdE1):** The complex identity of forensic science
Theme 2 (IdT2): Police forces possess ownership in forensic science, where they are natural partners with forensic science practitioners in the administration of justice.	**Exemplar 2 (IdE2):** The policing context required in forensic science
Theme 3 (IdT3): Judicial systems possess ownership in forensic science, where they have the power to change forensic science practice in a manner suitable for the courts.	**Exemplar 3 (IdE3):** The legal context required in forensic science
Theme 4 (IdT4): Forensic science holds a stereotyped image in relation to its role and capabilities.	**Exemplar 4 (IdE4):** The high-risk ethical and professional environment of forensic science
Theme 5 (IdT5): Forensic science has not yet developed as a profession.	**Exemplar 5 (IdE5):** The field of interest groups

Table-8d

In addition to reporting identity themes and exemplars, chapter 7 discussed implications for forensic science education which respond to such themes and exemplars. This chapter re-stressed the existence of social groups within forensic science that hold opinions and perceptions about forensic science- from an identity perspective- which might complement or contradict each other. Chapter 7 then discussed the complexity in introducing an educational approach which responds to the nature of forensic science identity and reflects its identity exemplars.

8.3- The Pedagogical Discourse across Knowledge, Practice, and Identity: Approaching the Epistemological Complexity of Forensic Science

Chapter 5 reported four knowledge exemplars comprising components of forensic science knowledge (Table-8b). Further examination into:

- these knowledge exemplars,
- the practice exemplars presented by chapter 6 (Table-8c),
- the identity exemplars revealed by chapter 7 (Table-8d), and
- the themes reported by the document analysis (Table-8a)

showed logical connections between these themes and exemplars. These connections have promoted a pedagogical discourse between forensic science knowledge, practice, and identity which has enabled the reconceptualising and recontexualising of the themes relating to forensic science knowledge.

This section will discuss the following notions of forensic science knowledge:

- The contextualised nature of the science component
- The theoretical nature of underpinning framework
- The tacit nature of the vocational component
- Essential forensic science capabilities

Following their identification, the research conducted a pedagogical discourse across the notions of forensic science knowledge in order to generate insights into the epistemological nature of forensic science.

8.3.1- The Contextualised Nature of the Science Component

The science component of forensic knowledge (KnE1) which is mainly experienced within forensic laboratory practices may only be termed ‘forensic’ once it is related to a legal context (IdE3). Relating science to law involves the policing context required in forensic science (IdE2). Most of the applications and techniques used by forensic chemists (e.g.

chromatography) are the same as those used by chemists in industries such pharmaceuticals, food, and cosmetics. Similarly, most of the applications and techniques used by forensic biologists (e.g. PCR) are the same as those used by biologists in cancer research and other biomedical applications. Chemistry is chemistry and biology is biology, but what makes the chemistry in forensic chemistry distinguishable from that in other fields of chemistry and what makes the biology in forensic biology distinguishable from that in other fields of biology is the object and context of study.

The tools used in forensic science are scientific (the chemistry in forensic chemistry and the biology in forensic biology), but the object of study in forensic science is legal such as to decide whether or not a crime scene exhibit belongs to a suspect. The recipients judging the scientific work of forensic chemists and biologists are non-scientific (PrT2). The experts with whom forensic chemists and biologist regularly deal are not all scientists (PrT2). Such unique features of forensic science (IdT1) make the context within which forensic scientists operate not a pure science context, but a combination of multiple- contexts: scientific, quasi-military (police), and legal. Such a combination of multiple-contexts suggests that the practice of forensic science is not only scientific. The forensic science field is also a social practice.

This combination of multiple-contexts constitutes the 'forensic context'. Hence, any scientific discipline may be termed 'forensic science' only after it has been 'forensically' contextualised.

8.3.2-The Theoretical Nature of Underpinning Framework

Logical connections between: KnE1 (the science component of forensic knowledge) with KnE2 (the vocational component of forensic knowledge) and consequently with PE1 (forensic science sensibility) reveal that the science component of forensic knowledge (KnE1) constitutes not only the foundation knowledge for forensic laboratory practices (e.g. forensic chemistry and forensic biology), but also the underpinning theoretical framework for the uniquely forensic vocational applications (e.g. crime scene processing and blood pattern analysis). For instance, blood pattern analysis (BPA) is an explicitly vocational forensic application (4^{th} Category of Description, chapter 5). However, BPA relies on the underpinning knowledge of 'physics, biology, chemistry, and mathematics' (PP2 and PP6). Physics for example, provides knowledge about 'the natural laws of motions... the types of force that may be subjected to matter... viscosity and surface tension', whereas biology underpins knowledge about the 'intrinsic and extrinsic clotting of blood and the characteristics of blood' (PP2, p.9). All of these underpinning science disciplines contribute to the practitioners' understanding of the 'way blood behaves' which 'influence the way practitioners interpret blood stains at crime scenes' (PP6, p.10).

The theoretical framework underpinning most of the field applications is not acknowledged by field practitioners in many instances. For example, most of the participating field practitioners (PP1, PP2, and PP4) have either considered that their every day practice has nothing to do with science or simply underpins crude science. This can be clearly reflected in the quotes addressed in chapter 5, section-5.2.2.2:

> *We don't use physics… in 26 years I've never had to use physics as means to explain a process in court…* (PP1, p. 3).
>
> *When you break down what we actually do, it's not rocket science, we're really just recording, collecting, putting in a bag, and passing it on for someone else to look at…* (PP2, p. 3).

The participating forensic science educators attributed such a denial from many field practitioners of the scientific framework underpinning their practices to the unawareness of these practitioners who 'unknowingly apply science in mainly everything they do' (EP2, p.4). Beckett and Hager (2002) have proposed an explanation which complements and further extends that of the participating forensic science educators. According to Beckett and Hager, many vocational practitioners do not acknowledge the theoretical (scientific) framework underpinning their applications and which they come across in their everyday practice, because they are either unaware of such framework, not interested in it, or more focused on completing the job in hand (2002). Such non-acknowledgement of the theoretical framework underpinning most of the forensic practices does not make it any less important.

8.3.3- The Tacit Nature of the Vocational Component

The vocational component of forensic knowledge (KnE2) comprises all uniquely forensic forms of inquiry. Such component, unlike the science one, is forensically intrinsic. In other words, these uniquely forms of inquiry cannot be applied but in a forensic context. For example, fingerprinting is only conducted for identification purposes. Another example is handwriting examination which is only conducted to investigate suspected cases of fraudulent signatures, wills, passports, etc.

The vocational component of forensic knowledge is mostly applied in field practices and applications. It mostly relies on experiential knowledge (KnT2) with theoretical knowledge underpinning the experiential one. Chapter 5 revealed consensus amongst all participants that the vocational component of forensic knowledge may only be acquired in practice-based settings, through exposure to hundreds of crime scenes and real practice sites. For instance, BPA requires an underpinning theoretical framework as discussed in the previous subsection. However, practitioners will not acquire BPA until they are 'exposed to real blood' and to 'how it might be distributed' and this may only be achieved within a real crime scene setting (PP3, p.7). Another significant quote which was addressed in chapter 5 (section 5.2.4.2) in this respect is:

> *I think blood is such a unique fluid, you have to sort of basically start from scratch with these terms in learning about blood in that context, I mean certainly I'd heard terms like viscosity and surface tension back at university but not in the context of blood pattern analysis, you'll only learn that within context on the job* (PP6, p. 8).

These direct quotes refer to PP3 and PP6 who are both scientists (laboratory practitioners) and defended the science nature of forensic science in nearly every discussion in their interviews. However, based on their experiences, they acknowledged that there is 'silent' forensic knowledge embedded within forensic science practice. This 'tacit knowledge' may only be acquired through workplace learning. The existence of tacit knowledge within the vocational component of forensic science was also suggested by document analysis which revealed that the practical component of forensic science knowledge requires a practice-based setting (DAT4). Hence, the vocational component of forensic knowledge comprises practical knowledge which is, to a greater extent, hidden within the crime scenes and across the different forensic science practices. The tacit nature of forensic knowledge explains the reason behind participants' emphasis on "learning by observation" as the required pedagogy to acquire practical forensic knowledge. Hence, mentoring constitutes one of the essential teaching and learning practices within forensic science.

The tacit knowledge within forensic science, according to all second group participants, is acquired through two stages of training:

- First, 'accompanying and observing qualified practitioners whilst working on field and at lab' (PP1, p.6). At such a level, having a forensic sensibility of the crime scene (PrE1) underpins the development of a distinctively forensic practice by novice practitioners. Such sensibility develops when novice practitioners start cultivating the hidden knowledge needed to assess the crime scene and to apply the various forensic science procedures.

- Second, novice practitioners gradually experiment with the cultivated knowledge as they encounter practical challenges. Their practical competencies are acquired in a manner proportional to the identified tacit knowledge. In other words, the more tacit knowledge they reveal, the more practical knowledge they acquire by expressing such knowledge- which is no longer tacit for them- through practical capabilities. During this period of training, novice practitioners are more aware of their forensic sensibilities and more proficient in their forensic competencies.

When novice practitioners complete these two stages over a given period of time- often over several years- they are assessed against a number of examination boards. Once they have passed all assessments, they become accredited to conduct their jobs independently after having practically expressed a great deal of the tacit knowledge embedded within their practices. At such a level, these practitioners are ready to complete tasks accompanied by novice practitioners who will shadow and observe them practicing at crime scenes, where the teaching and learning cycle starts all over again.

8.3.4- The Essential Forensic Science Capabilities

Across the science component of forensic knowledge, the theoretical framework underpinning the practical components of forensic science, and the vocational component of forensic science, there exist forensic competencies which had been reported by the participants as essential from both a knowledge perspective (KnE4), and a practice perspective (PrE3). These competencies are critical thinking and communication skills. Critical thinking and communication skills were also emphasised by a number of the selected forensic science courses (e.g. FOR-715, FOR-558, FOR-560, and FOR-766) in the document analysis (section-4.5.1, chapter 4). Both of these competencies are required within and across every component of forensic science knowledge and every stage of forensic science practice. Table-8e presents how these competencies are required at various levels of forensic science knowledge and practice.

	Critical Thinking	**Communication Skills**
Science Knowledge	Required to 'forensically' contextualise science knowledge invited into forensic practice	Expressing the scientific discourse through a forensic discourse
Theoretical Framework	Identifying the theoretical framework underpinning practical applications within forensic science	Communication of the theoretical framework in a manner which acknowledge it without shifting the focus from the task itself
Tacit knowledge	Revealing the silent knowledge embedded within practice	Communicating the revealed silent knowledge into practical terms
Practice Complexities	▪ Management of the unexpected challenges of the crime scene ▪ Defensibility of their evidence/opinions at court	▪ Communication with practitioners of various professions and backgrounds ▪ Critical communication of scientific and technical language in plain non-scientific and non-technical language

Table-8e

8.3.5- The epistemological Nature of Forensic Science

Linking the previous 4 subsections (8.3.1, 8.3.2, 8.3.3, and 8.3.4) of the discussion suggests the existence of four zones of knowledge within forensic science:

- Zone 1: Extrinsic forensic science knowledge.
  This zone of knowledge comprises science knowledge which is only termed 'forensic science' once it is contextualised into a forensic setting. Zone 1 has a paramount existence in laboratory practice (e.g. forensic chemistry and forensic biology).

- Zone 2: Intrinsic forensic science knowledge
  This zone of knowledge encompasses forensic forms of inquiry which are explicitly

forensic in nature and context (e.g. crime scene investigation, fingerprinting). Zone 2 has a predominant existence in field practices and contains sub-zones of tacit knowledge embedded within the practice settings of forensic science.

- Zone 3: The intersection between zones 1 and 2.
  This zone of knowledge represents the theoretical framework which emerges from zone 1 to underpin the practical applications located within zone 2 (e.g. BPA).

- Zone 4: The essential forensic competencies
  This zone comprises the essential forensic capabilities which are applied within each of the above three zones and across these zones.

These four zones of knowledge are represented in the following Venn-Diagram (Figure-8a).

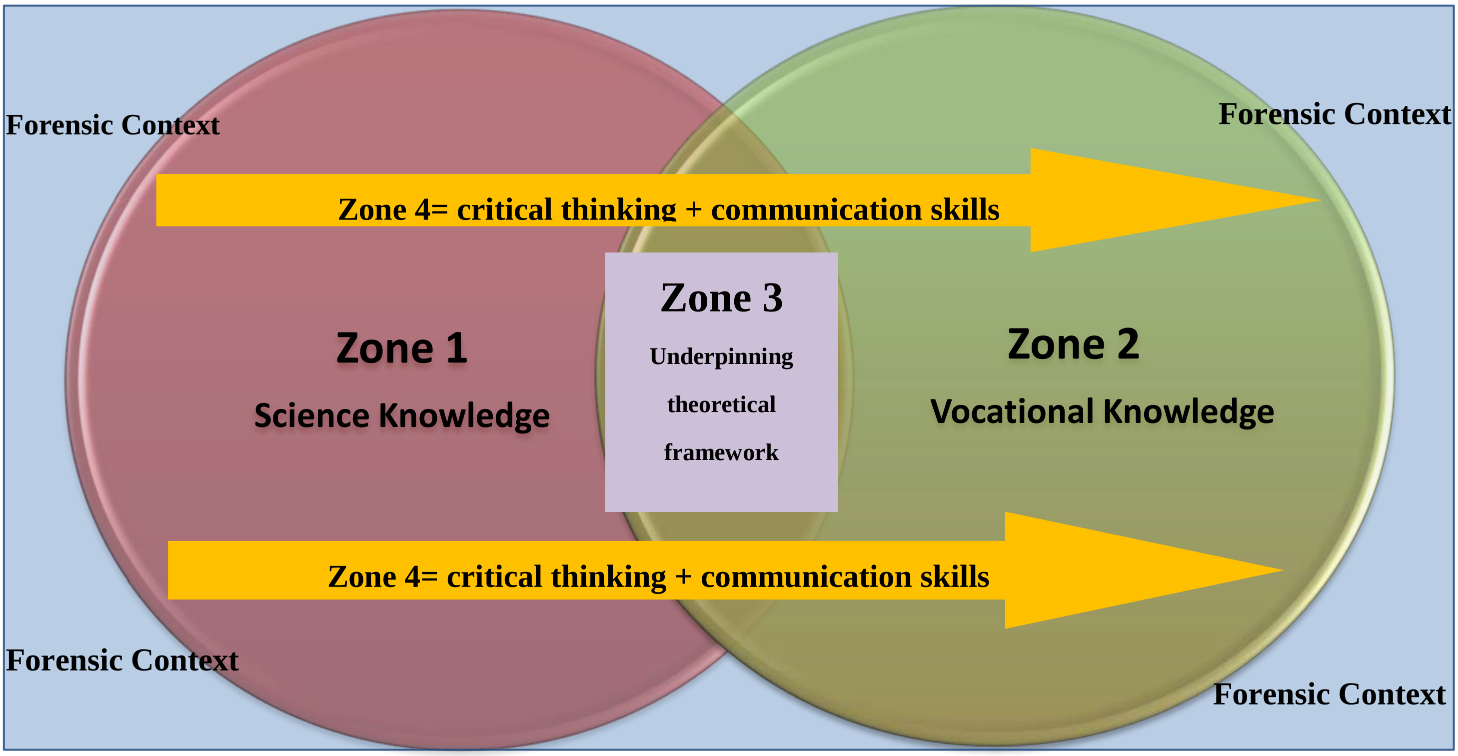


Figure-8a

The forensic context, within which any invited or embedded form of knowledge and inquiry is applied, is the outcome of the integration of three "**subcontexts**":

- The legal subcontext (IdE3 & DAT6): This subcontext emerges from the ownership by the judicial system of forensic science (IdT3). This ownership is reflected in every stage of forensic science practice: the way the crime scene is processed, the acts relevant to the collection, testing, and analysis of each type of evidence (physical and biological), the conditions for admissibility of evidence by the courts, the outline and the manner through which reports are communicated to the courts, and the way forensic practitioners present their evidence/opinion in courts (including the manner through which they are cross-examined).

- Policing subcontext (KnT2, IdE2 & DAT7): This subcontext emerges from the police ownership in forensic science- particularly the absolute ownership of nearly all field practices which are predominantly vocational in nature. Hence this subcontext is mainly represented through both police practices and guidelines related to forensic science practice. For example, forensic investigation including a firearm analysis needs to be conducted by a forensic expert who is a sworn police officer or in the presence of a sworn police officer; in which case it requires expertise from other disciplines (e.g. forensic pathology or forensic biology).

- Scientific subcontext (KnT1 & DAT4): relates to the scientific nature of forensic knowledge, where science disciplines are the major disciplines in laboratory practice and underpinning disciplines in the field practice.

The integration of these three sub-contexts is uneasy and complex. This is because there is no possible way through which each of these subcontexts is proportionally represented in such integration. The extent to which one subcontext dominates over the other two is dependent on a number of factors which will be explored after identifying the forensic power groups that support each of these subcontexts (section 8.4) and the cultures represented by such subcontexts (section 8.5).

8.3.6- The Nature of Forensic Science Knowledge: Summary of Findings

Forensic science knowledge comprises four zones of knowledge. Zone 1 encompasses the forensically extrinsic science knowledge. Zone 2 comprises the forensically intrinsic vocational knowledge. This vocational knowledge involves subzones of tacit knowledge which require practice-based learning to translate such silent knowledge into active practical competencies. The intersection between zones 1 and 2 gives rise to zone 3: the theoretical (science) framework underpinning forensic practical applications. Within and across these three zones, critical thinking and communication skills are essential competencies. These competencies comprise zone 4 of forensic knowledge. The forensic context, within which all four zones of knowledge are intrinsically or extrinsically applied, is the result of a complex integration of three subcontexts: scientific, police, and legal.

8.4- The Pedagogical Discourse across Knowledge, Practice, and Identity: Approaching the Nature of Forensic Science Practice

In this section, the research discusses the segmented nature of forensic science practice and the power groups which exist within the forensic science field. Such discussion takes the form of a discourse across the identified conceptions relating to the nature of forensic science practice in each of chapters 4, 5, 6, and 7.

8.4.1- The Segmented Nature of Forensic Science Practice

The segmented nature of forensic science practice between laboratory practice and field practice has been emphasised by the identified themes emerging from both document analysis and the analysis of semi-structured interviews:

- Chapter 4: The nature of forensic science practice differentiates between field practice and laboratory practice (DAT5).
- Chapter 5: The nature of forensic science knowledge is more scientific in laboratory practice (KnT1) whilst more vocational in field practice (KnT2).
- Chapter 6: Forensic science practice is of a segmented nature divided between forensic laboratory practitioners and forensic field practitioners (PrT4).
- Chapter 7: Forensic science has not developed as a unified profession (IdT5).

A summary of the data which emphasises the differentiation in the nature of forensic science practice between laboratory practitioners and field practitioners is presented in Table-8f.

	Table-8f: Segmentation between laboratory practice and field practice as revealed by the 4 chapter of data analysis	
	Examples of data(conceptions, perceptions, and positions) emphasising segmentation	**Reference**
Document Analysis	Differentiation exists between forensic field practice and laboratory practice in terms of: **education** (heavy specialised science courses targeting laboratory positions versus non-specialised science courses targeting field positions), **prerequisites** (laboratory positions require science qualifications, while field positions often do not), and **identity of practitioners** (laboratory practitioners who are often civilians versus field practitioners who are often sworn police officers).	Section 4.6, Chapter 4.
Forensic Science Knowledge	All participating laboratory practitioners hold/are undertaking a specialised science qualification, while the majority of the participating field practitioners do not hold a science qualification.	Subsection-5.2.1.2, chapter 5
	All participating laboratory practitioners argued for the science nature of forensic knowledge, while all participating field practitioners argued against the science nature of forensic knowledge and stressed that the knowledge they apply in their everyday practice is purely experiential.	Subsection-5.2.2.2, chapter 5
	All participating laboratory practitioners argued that a science qualification is a necessity for the practice of forensic science, while all participating field practitioners argued that it is not.	Subsection-5.2.5.2, chapter 5
Forensic Science Practice	Differentiation between laboratory practice and field practice starts with the prerequisites for employment, training, accreditation, and extends to cover the amount of science done in the field versus that undertaken in the laboratory.	Table-6d, subsection-6.3.3, chapter 6
	Laboratory practitioners enjoy access to both laboratory, and field work; on the other hand, field practitioners have restricted access to laboratory work.	Table-6d, subsection-6.3.3, chapter 6
Forensic Science Identity	All participating laboratory practitioners are civilians, whilst all the participating field practitioners are sworn police officers.	Subsection-7.4.3, chapter 7
	The majority of laboratory practitioners favoured a completely independent structure of forensic science from police departments, while the majority of field practitioners favoured a completely dependent one.	Table-7f, subsection-7.2.2.2, chapter 7

As revealed by this Table-8f, segmentation between laboratory practice and field practice covers:

- The knowledge base of both groups: scientific versus vocational/technical (chapter 5)
- The nature and extent of practice: scientific and unrestricted access versus vocational and restricted access (chapter 6)
- The identity of the practitioners in each group: civilian scientists versus technically specialised sworn police officers (chapter 7)
- The perceptions of the participating forensic laboratory practitioners and the participating forensic field practitioners which complemented some conceptions but conflicted on most issues relating to forensic science knowledge, practice, and identity (chapters 5,6, and 7).

In addition, differentiation between the two practices (laboratory versus field) was reflected by the published curricula of forensic science courses (chapter 4). Document analysis emphasised that laboratory practice is often conducted by civilians, whereas field practice is often conducted by sworn police officers. In addition, document analysis revealed that the non-award degrees which are non-scientific degrees and award degrees which are not specialised science degrees are more directed towards forensic field career opportunities and current field practitioners. On the other hand, specialised science courses are more directed towards forensic laboratory career opportunities and current laboratory practitioners.

Based on the above discussion, the segmentation in the nature of forensic science practice between laboratory practice and field practice is not restricted to one aspect or conception. It extends to comprise the nature of knowledge underpinning each of the two practices, the nature of the tasks and responsibilities included in each of these practices, the identity revealed by each of the two practices, the beliefs and perceptions generated within these practices, and finally the education targeting each of the two practices. This suggests that differentiation between these two practices is more of an ontological nature, where differentiation relates to the nature of each type of practice.

Data analysis in chapter 6 revealed that segmentation also exists within field practice, where each speciality area within such practice possesses its own requirements, prerequisites, accreditation process, and publications (PrE4). This segmentation will not be taken into consideration by the research when discussing the following subsections of this chapter: forensic power groups (subsection-8.4.2), the cultures existing within the forensic science field (subsection-8.5.1), and the paradigm shift within forensic science (subsection-8.5.2). This is because, as a group, field practitioners- regardless of the differentiation which exists between the various incorporated speciality areas- possess homogeneity in terms of the vocational nature of their tasks, their military identity as sworn police members, and consequently their perceptions of forensic science in terms of its knowledge, practice, and identity as reflected by Table-8e. However, the research will take into consideration the segmentation which occurs amongst field practices which results in the emergence of minor communities of forensic practice in two perspectives:

- In supporting the belief that forensic science is not a stand-alone profession (IdT5) but rather a field of interest groups (IdE5), and
- In addressing the complexities which face forensic science education, particularly the difficulty in organising a higher education forensic science program which can liaise with all minor forensic communities of practice. This will be part of the discussion which will take place in chapter 9.

8.4.2- The Forensic Power Groups

The research has adopted Bernstein's notion of 'power and control', where 'social groups' who are stakeholders of an education code exert power and control over such code (2000). Power and control are reflected in the way these groups prefer to represent the knowledge related to their field (Bernstein, 2000). Bernstein's notion was first suggested by the document analysis in theme 8, where most of the courses revealed the contribution of forensic science practitioners in course delivery. Such contribution reflects in one way or another attempts by forensic science practitioners, as being a forensic social group, to reflect their preferences in organising and structuring forensic science knowledge. Bernstein's notion has then been strongly suggested in each of the data analysis chapters of the semi-structured interviews (chapters 5, 6, and 7). In these chapters, interviewees' backgrounds, perceptions, and positions towards a variety of issues reflected the existence of a number of social groups who have their preferences in the way forensic science knowledge is organised, practiced, and represented. The research will adopt the term **'forensic power groups'** to represent those social groups who are involved in or associated with forensic science and hold preferences towards representing forensic science knowledge and the organising of academic forensic science programs.

In the research methodology, the involvement of three groups of participants in the semi-structured interviews prompted the notion of forensic power groups, where each group was formed as a result of its social relation to forensic science. Each group of participants represents one of three social relations to forensic science:

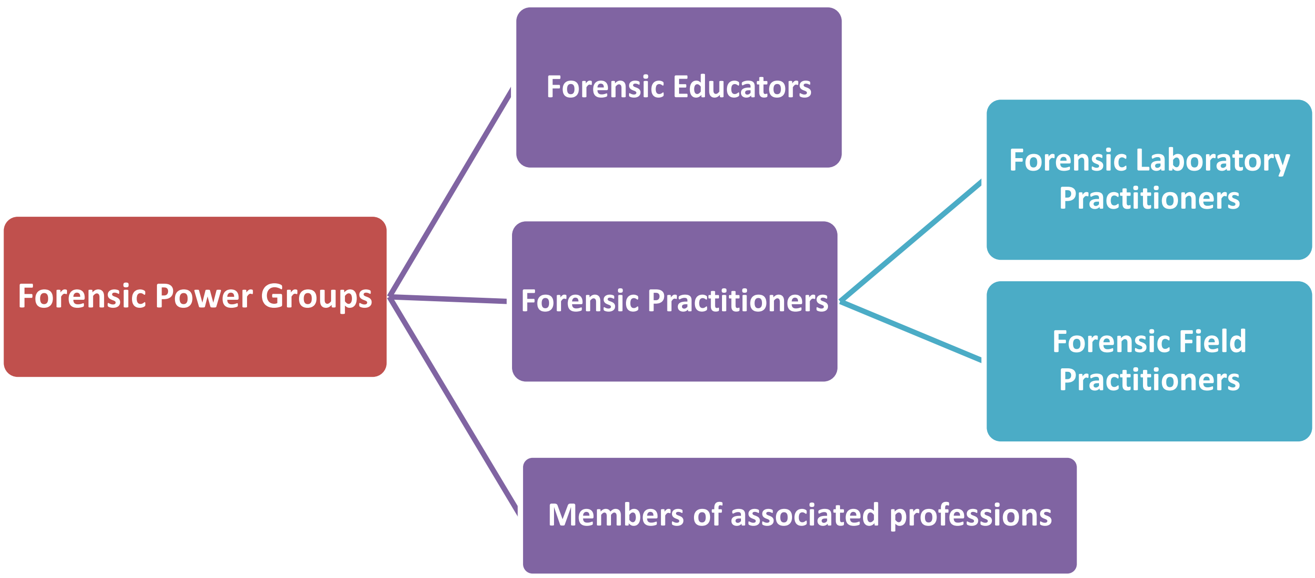
- Forensic science educators (1st group participants): represent the educational relation to forensic science. Through such representation, they provide an educational view of forensic science.
- Forensic science practitioners (2nd group participants): represent the practice relation to forensic science. Through such representation, they provide an internal view of forensic science.
- Members of associated professions (3rd group participants): represent a bona-fide relation to forensic science. Through such representation, they provide an external view of forensic science.

As the research progressed in terms of data coding and analysis, the researcher became more confident in the adoption of Bernstein's notion of social groups. However, data collected from semi-structured interviews emphasised the need of re-structuring of these three groups (forensic science educators, forensic science practitioners, and members of associated professions) to become more representative of the forensic power groups. Re-structuring will be conducted in several phases. Re-structuring will respond to differences and similarities between the positions and perceptions of various participants in relation to forensic science knowledge, practice, and identity as revealed by the data analysis of the semi-structured interviews. Each of the phases of re-structuring will be presented in a separate subsection and summarised in a diagram.

8.4.2.1- The First Phase of Re-structuring: Segmentation of Forensic Practitioners

The previous section (section-8.4.1) discussed the segmented nature of forensic science practice which clearly suggested that forensic science practitioners differentiate into two groups: laboratories practitioners and field practitioners. Laboratory practitioners are the more scientifically oriented forensic practitioners, whilst field practitioners are the more vocationally and military (police) oriented forensic practitioners. Hence, in this phase of re-structuring, the three forensic power groups: forensic educators, forensic practitioners, and members of associated professions are re-structured into four forensic power groups: forensic educators, forensic laboratory practitioners, forensic field practitioners, and members of associated professions. This re-structuring is presented in Figure-8b.

Figure-8b: The First Phase of Re-structuring (segmentation)



8.4.2.2- The Second Phase of Re-structuring: Segmentation of Members of Associated Professions

Members of associated professions (3rd group participants) were selected amongst those personnel who possess a bona-fide relation with forensic science. The participants of this group comprised three professions associated with forensic science: forensic psychology (AP1), police (AP2), and legal profession (AP3 and AP4). Throughout data coding and analysis of the semi-structured interviews, it was becoming more apparent that the practitioners of these three professions were hardly in consensus on any of the forensic science concepts. This suggested that the decision to incorporate these participants into the one group (members of associated professions) was simplistic and requires further development. Examples on the differentiation in the position and stance amongst the third group participants are:

- On the importance of science knowledge to forensic practitioners, AP1 together with AP3 and AP4 emphasised such importance, whilst AP2 did not regard it as important particularly for field practitioners (subsection-5.2.2.3, chapter 5).

- On the need for tertiary forensic science education, AP2 argued completely against it, AP1 argued for it, whilst AP3 and AP4 argued for tertiary education for forensic laboratory specialisations (subsection-7.2.4.3, chapter 7).

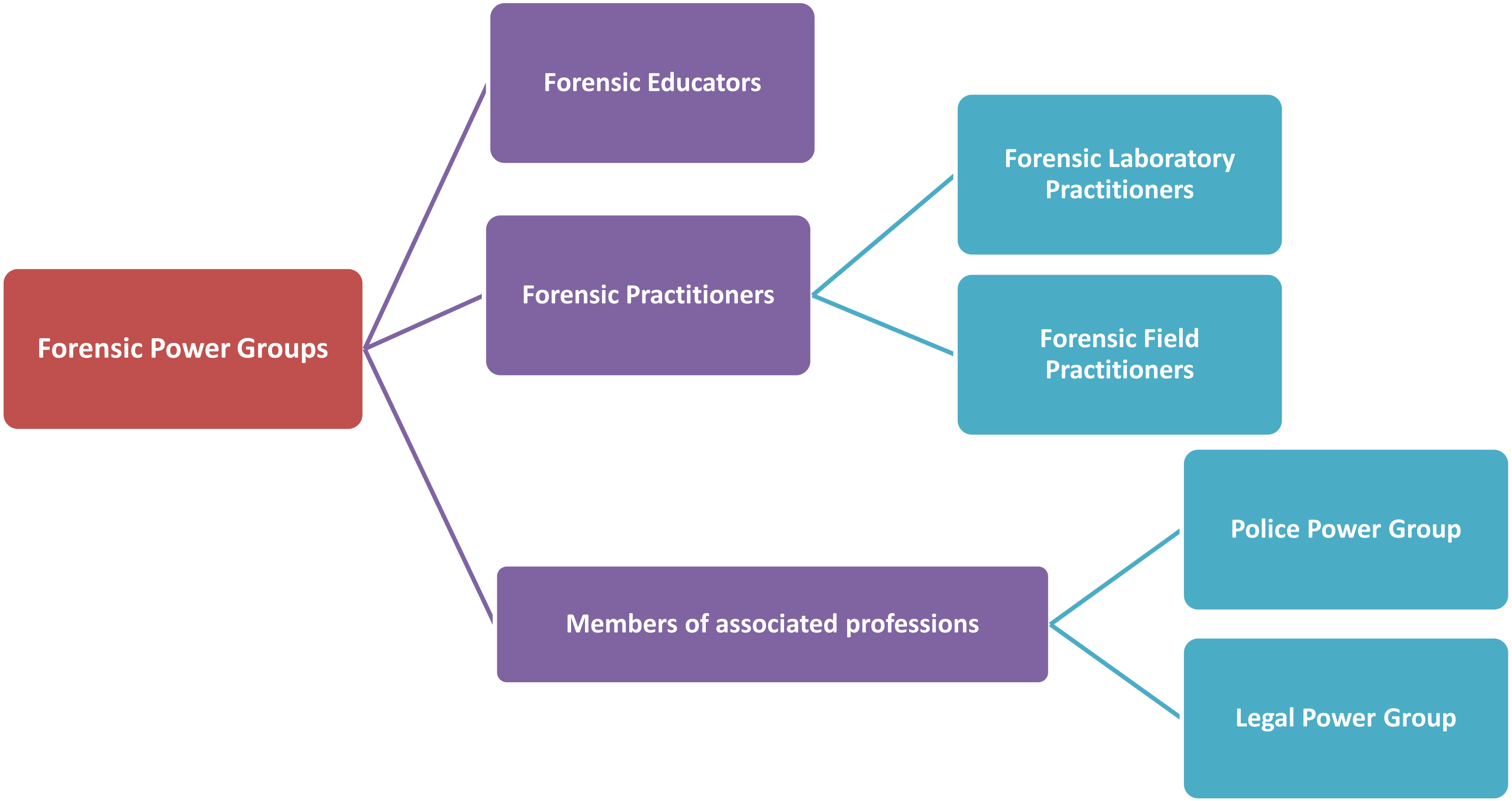
- On their preference of the identity of the administering department of forensic science courses, AP2 showed indifference towards such identity, AP4 preferred a stand-alone forensic science department, whilst AP1 preferred a multidisciplinary forensic science course with contributions from various departments.

Given the differences in their backgrounds and professions on the one hand, and the differences in their perceptions and standpoints on most argued concepts on the other hand, AP1, AP2, and AP3& AP4 represent forensic power groups that are differentiable from one another. Hence, members of associated professions need to be segmented into three forensic power groups: forensic psychologists power group (AP1), police power group (AP2), and legal power group (AP3 and AP4). However, forensic psychology in addition to a number of forensic disciplines such as forensic pathology and psychiatry do not fall within the research working definition of forensic science (criminalistics). Hence, the psychology power group will not be included amongst the re-structured forensic power groups. This constitutes one of the limitations of this research which will be further discussed in chapter 9.

Based on the above discussion, members of associated professions are segmented into two forensic power groups: police power group (AP2) and legal power group (AP3 and AP4). The formation of the police power group was informed by Theme 2 of chapter 7 which stressed police ownership in forensic science. It was also informed by the remarkable perceptions and positions of AP2 on a number of issues which clearly reflected the police's interest regardless of the interest of the forensic science field. For instance, AP2 was the only participant of his group (third group participants) who argued for a semi-dependent structure for the operation of forensic science, while the majority of the group argued for a completely independent structure for such operation. Another example is that AP2 was the only participant of his group who denied any major or considerable influence of the police on the identity of forensic science. In such a position, AP2 is naturally defending the police department from the continuous accusations of interference in forensic investigation. Defence barristers, as part of their defence strategy, continuously accuse police departments in biasing the forensic science results in a manner which would privilege the results of any criminal investigation conducted by the police. These accusations were highlighted by a number of participants (PP4 and PP6 in subsection-7.2.2.1, and AP3 and AP4 in subsection-7.2.2.3 of chapter 7).

The formation of the legal power group was informed by Theme 3 of chapter 7 which emphasised judiciary ownership in forensic science. Such formation was also informed by the remarkable perceptions and standpoints of both AP3 and AP4 on a number of issues which clearly reflected the legal practitioners' interests at the expense of what is important for forensic science practitioners. For instance, AP3 and AP4 were the only interviewees amongst all participants who assertively argued against the need for a legal component to be incorporated within the forensic science knowledge base (section-5.3.2, chapter 5). The majority of the participants stressed the importance of inclusion of a moderate legal component within forensic science education and training. In such a stance, the position of AP3 and AP4 raised the question on whether or not it is in the interest of the legal practitioners that forensic practitioners remain of limited legal knowledge as more in depth legal knowledge may threaten these practitioners, particularly defence barristers in their conflict with forensic practitioners. The re-structuring undertaken in this phase is presented in Figure-8c.

Figure-8c: The Second Phase of Re-structuring (segmentation)



8.4.2.3- The Third Phase of Re-structuring: Merging Forensic Science Educators with Forensic Laboratory Practitioners

Cross- comparison across the backgrounds, positions, and perceptions of the participating forensic science educators and the participating laboratory practitioners clearly suggested that these two forensic power groups can be merged together under the one forensic power group: the scientific power group. A summary of this cross-comparison is presented in Table-8g. As revealed by this table (Table-8g), forensic science educators and laboratory practitioners can be merged into the one power group for the following reasons:

- Both groups are of same or similar science backgrounds.

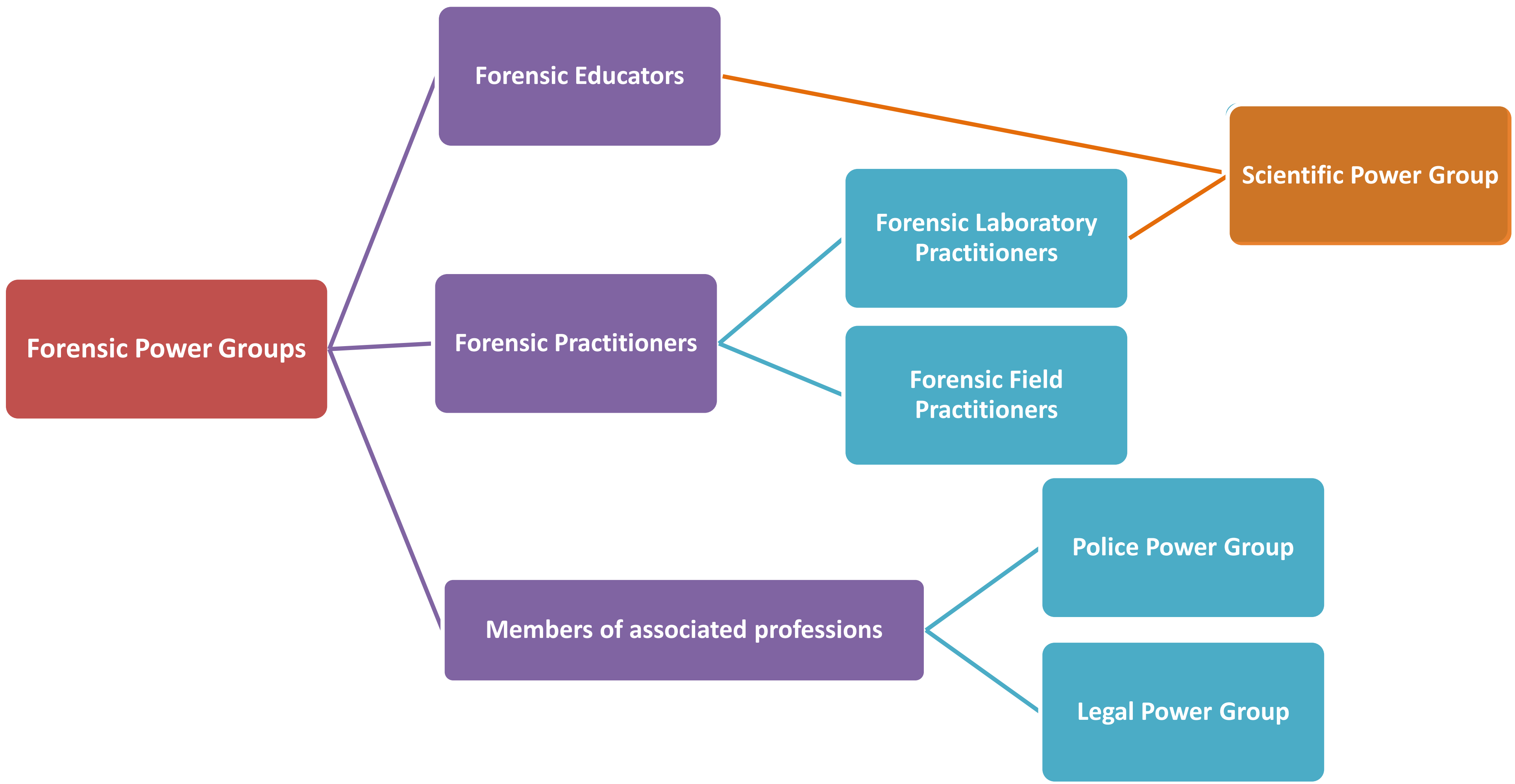
- Most of the participating forensic science educators practiced as laboratory practitioners before complete dedication to education and training in forensic science.

- Both groups held similar or the same stances in nearly all conceptions towards forensic science knowledge, practice, and identity. Such stances defended the scientific nature of forensic science.

Hence, in this phase of re-structuring, forensic science educators are merged with forensic laboratory practitioners into the one forensic power group: scientific power group. Hence, at the conclusion of this phase of restructuring, the forensic power groups are re-structured into four power groups: scientific power group, field practitioners, police power group, and legal power group. This re-structuring is presented in Figure-8d.

	Table-8g: Similarity between the backgrounds, stance, and perceptions of the participating forensic science educators and the participating laboratory practitioners	
	Examples of the backgrounds, perceptions, and positions emphasising similarity	**Reference**
Forensic science knowledge	Both the participating forensic science educators and forensic laboratory practitioners are of same or similar science backgrounds. For example, EP1, EP4, PP3, and PP6 are biologists- particularly molecular biologists (genetics). EP2, EP3, and PP5 are chemists- particularly analytical chemists.	Table-5a & Table-5b, subsection-5.3.1, chapter 5
	Most of the participating forensic science educators (EP1, EP2, and EP4) practiced as laboratory practitioners before completely dedication to education and training in forensic science.	Subsection-5.2.1.1, chapter 5
	Both the participating forensic science educators and forensic laboratory practitioners argued for the scientific nature of forensic knowledge and the requirement to be competitive scientists.	Table 5d, Subsection-5.3.2, chapter 5
Forensic science practice	Both the participating educators and laboratory practitioners emphasised that both science education and practical experience are a ‘winning combination’. This combination enables forensic practitioners to do both laboratory and field work; giving them a holistic awareness of forensic science practice.	Table-5h, subsection-5.3.5, chapter 5 and Subsections 6.2.3.1 & 6.2.3.2, chapter 6
Forensic science identity	Both the participating educators and laboratory practitioners argued against the dependent police-structure for operating forensic science (preferred either semi-independent or completely independent structures) in order to maintain the scientific mindset of the forensic practitioners.	Table-7e & Table-7f, subsections 7.2.2.2 & 7.2.2.1, chapter 7
	Both the participating educators and laboratory practitioners had concerns about starting forensic science education at an undergraduate level; however, both argued for postgraduate forensic science education.	Table-7j, Subsection-7.3.3, chapter 7.

Figure-8d: The Third Phase of Re-structuring (merging)



8.4.2.4- The Fourth Phase of Re-structuring: Merging Forensic Field Practitioners with the Police Power Group

In this phase of re-structuring, field practitioners are merged with the police power group. Such a re-structuring decision has been informed by examining the positions and perceptions of the participating field practitioners (PP1, PP2, and PP4), who are all sworn police officers, against those of AP2, who is a senior police advisor and explicitly represents the stance of the police department. Positions and perceptions of the participating field practitioners nearly complemented those of AP2. Examples of such agreement are:

- In relation to the need for science education for forensic science practitioners, AP2 clearly emphasised that from a police perspective a number of forensic field areas do not necessarily require science education or a tertiary science qualification. According to AP2, the experience of a forensic practitioner is much more important than any qualifications. This is clearly emphasised in the following quote (previously addressed in section-5.2.5.3, chapter 5):

  > *I don't think as a police officer, when you're seeking the service of forensic scientists that you're particularly concerned in exactly what their tertiary qualifications are… Certainly from a police point of view, a number of forensic science fields don't necessarily require tertiary qualification. There are certainly some fields where people can be experts through experience …* (AP2, p. 1).

  Complementing this view point, participating field practitioners stressed on more than one occasion, during their interviews, that what they perform on a daily basis has nothing to do with science and is only based on experience. This is clearly reflected in the following quotes, which are only few of the many quotes emphasising such position.

  > PP1: *The knowledge we apply in our everyday practice is technical based* (p.2)… *in 26 years [in my profession] I've never had to use physics* (p. 3)… *all the physics wouldn't help you with the mechanical side of firearms identification* (p.6).
  >
  > PP2: *You certainly don't need a degree* [to practice as a crime scene investigator]… *the best examiners that we have here don't hold science degrees*… (p. 8).

- On the need for forensic science education in academia, AP2 opposed the other participants in his group (members of associated professions) in arguing against such education (subsection-7.2.4.3, chapter 7). Similarly, field practitioners opposed laboratory practitioners in arguing against tertiary forensic science education and in emphasising its disadvantages (subsection-7.2.4.2, chapter 7).

- On the preferred model under which forensic science needs to operate, both AP2 and the participating field practitioners argued that forensic science needs to operate under police management. However, AP2's preference was that forensic science operate under a semi-independent structure from the police, while two of the three participating field practitioners (PP1 and PP2) favoured a completely police dependent structure for forensic science to operate under. By doing so, they were "more royal than the king" (AP2)! However, this was one of the many opportunities where the participating field practitioners reflected their absolute loyalty to the police culture.

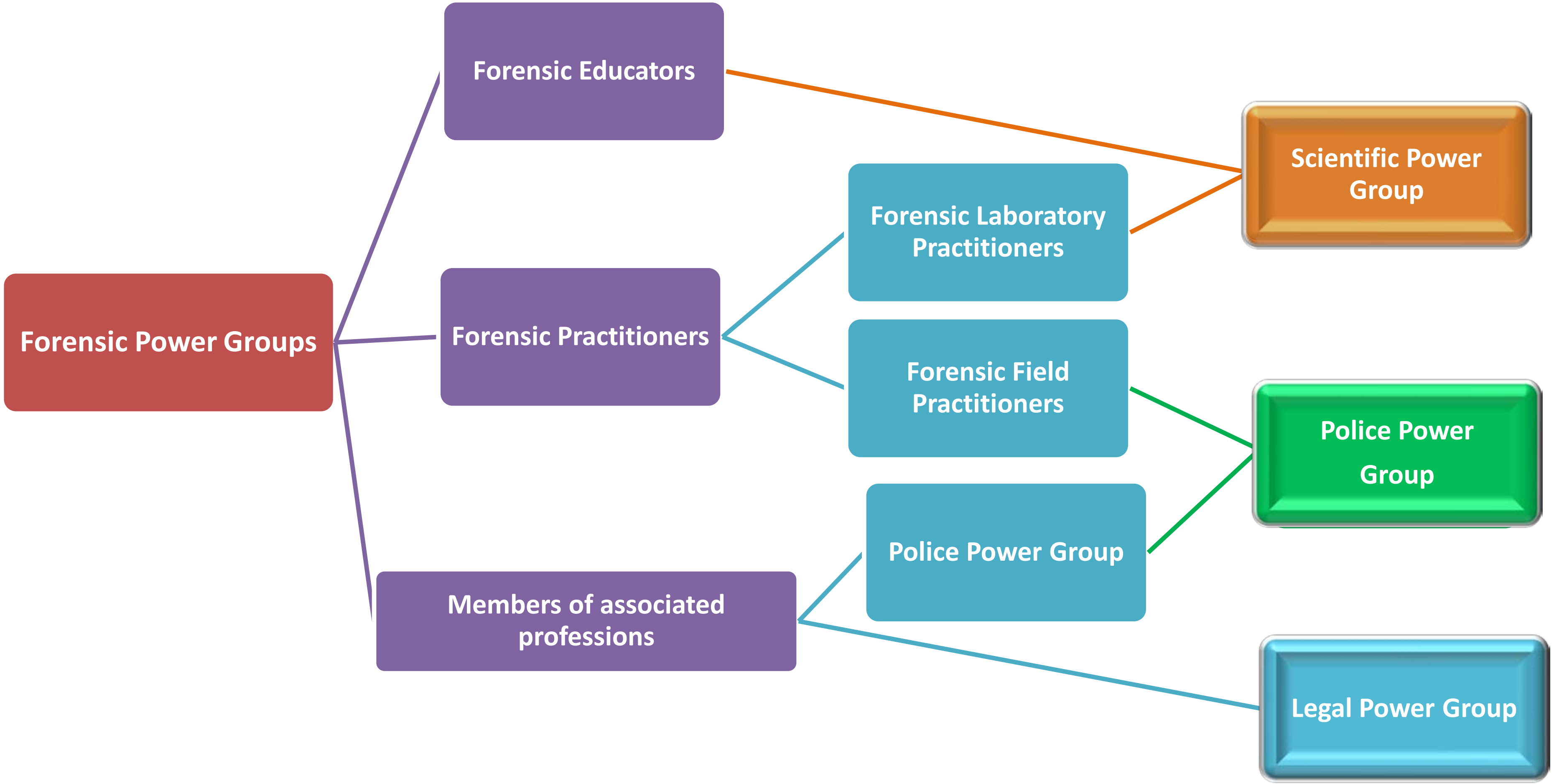
These examples suggest that the loyalty of the participating field practitioners to the police outweighed their loyalty to their forensic field of practice. In this respect, a remarkable observation is the stance of PP2. PP2 is the only participating field practitioner who holds a tertiary chemistry degree. This science background did not make PP2 any more appreciative of the science nature of forensics than the other participating field practitioners (PP1 and PP4). On the contrary, PP2 was the most aggressive amongst all participating field practitioners in attacking the science nature of forensics, the need for science education for field practitioners, and the introduction of forensic science education in academia. The following quote is one of many which reflect PP2's strong argument against the science nature of forensics.

Being able to lift a fingerprint or take the photograph of the shoe impression or clot the sample of blood, do you need a degree for that? I don't believe so… I neither do practice as a scientist nor go to the depth scientists would need to go in terms of their analysis…all the new technologies in the field doesn't make my work any scientific… I'm using this equipment now and this equipment dumbs down science. There is one button to push and you read the display and your instruments would get calibrated when it needs to. It's not difficult, you just need to be trained on how to use the *equipment which doesn't require you to be scientific or smart… the science and the smartness go out to these engineers who are designing the equipment for us… they're the ones who need a 'pat on the back'* (PP2, p.9).

The stance of PP2 shows that his police culture and mindset overcame his science culture and mindset. This culture conflict in forensic science will be further explored and discussed in the following section.

As a summary, field practitioners, represented by PP1, PP2, and PP3, seems to be more loyal to their police mindset and culture than to their forensic field of practice. Therefore, field practitioners are merged with the police power group (Figure-8e). With the conclusion of the four phases of re-structuring, three main forensic power groups have been identified in this research: **scientific power group**, **police power group**, and **legal power group**.

Figure-8e: The Fourth Phase of Re-structuring (merging)



8.4.3- The Nature of Forensic Science Practice: Summary of Findings

Forensic science practice is mainly segmented between laboratory practice and field practice. Segmentation also occurs amongst various specialisations existing within field practice. Segmentation between laboratory practice and field practice and across field practice supports the belief that forensic science has developed as a profession; it is merely a combination of various interest groups which in some instances might have nothing in common but their goal to assist in justice administration.

Within forensic science, the research identified three main forensic power groups: scientific power group, police power group and legal power group. These power groups represent different cultures which exist and conflict within forensic science, a notion which will be further discussed in the following section. These power groups have their preferences in the context within which forensic science knowledge is organised (curriculum) and delivered (pedagogy). Hence, any forensic science education decisions need to acknowledge these preferences. This concept will be further discussed in the following chapter (chapter 9).

8.5- The Pedagogical Discourse between Knowledge, Practice, and Identity: Approaching the Identity of Forensic Science as a Field of Study and Practice

As a field of study, forensic science identity showed a great deal of uncertainty in both document analysis (DAT3) and semi-structured interviews analysis (Table-7k, subsection 7.3.4) in relation to:

- Whether or not tertiary forensic science education is a need
- academic level at which such an education may start, and
- the identity of department under which forensic science courses are administered.

As a field of practice, uncertainty in forensic science identity was also reflected in both document analysis (DAT6) and semi-structured interviews analysis (IdT1, IdT2, IdT3, and IdT5) in relation to:

- The unconfirmed social status of forensic science as a profession,
- The nature of forensic science practice which is influenced by the individual jurisdiction under which it operates, and
- Multiple-ownerships and multiplicity of influencing factors.

In this section, the research will show that the uncertainty in the identity of forensic science as a field of study is nothing but a reflection of the uncertainty in the identity of forensic science as a field of practice; which in its turn is a reflection of a hidden conflict between the three forensic power groups (scientific power group, police power group, and legal power group) and their representative cultures.

8.5.1- Cultures Conflict: Three Cultures, One Field!

The identified three forensic power groups in the previous section are nothing but representatives of three cultures which exist within forensic science: science culture, police culture and judicial culture. Each of these cultures possesses ownership in forensic science and influence forensic science as a result of such ownership.

<u>Science Culture</u>

The science culture is represented by the science power group of forensic science. This power group considers the nature of forensic knowledge to be scientific to a greater extent (KnT1). The context of this culture is represented in knowledge zone 1 (science knowledge) and zone 3 (scientific theoretical framework underpinning vocational forensic applications) reported in section-8.3.5. These zones of knowledge require forensic practitioners to possess a scientific mindset. Such scientific mindset requires forensic practitioners to first propose a hypothesis, then attempt to test it, and validate it before accepting or rejecting such a hypothesis (Graziano & Raulin, 1993). In doing so, their conclusions are subject to refutation and falsification which is more or less a reflection of the empirical scientific nature of such conclusions (Popper, 2002).

<u>Police Culture</u>

The police culture is represented by the police power group of forensic science. This power group considers that the nature of forensic knowledge is vocational (practical) to a greater extent (KnT2). The context of this culture is reflected in knowledge zone 2 (vocational knowledge). The police culture is one of “quasi-military hierarchies” (Hunter et. al, 2004) and possesses a mindset of command, control, and unavoidable violence (Coady et al., 2000). Such culture is maintained within forensic science through:

- Forensic practitioners who are sworn police officers,
- The natural partnership which exists between police and forensic science, where the police members are responsible for securing the crime scene and the transfer of forensic evidence, and where police investigators guide what forensic science needs to investigate and where to investigate based on their interrogations and intelligence.
- Police management of forensic science centres and laboratories in models where these centres and laboratories operate in complete or partial dependence on the police.

Judicial Culture

The judicial culture is represented by the legal power group of forensic science. This culture is an adversarial, hierarchical and bureaucratic one rich in conventions and traditions (Ostrom et al., 2007). Such culture is characterized by the legal mindset, a mindset mainly based on logic where acceptance of presented evidence is conditioned by the evidence being “beyond reasonable doubt” (Houck 2006; Giannelli 2006).

Members of the legal power group are in direct interactions with forensic practitioners, specifically at courts during evidence presentation and cross-examination. The judicial culture is maintained within forensic science through the legal context to which any forensic analysis or interpretation is related prior to submission to a court.

Culture Conflict

Conflict predictably occurs between the science culture on the one hand, and the police and judicial cultures on the other. This conflict occurs on various levels and in various situations.

Conflict between the science culture and the police culture is mainly represented by the conflict between an open mindset which aims only to seek truth by following empirical scientific procedures and a quasi-military mindset which aims to bring about prosecution by following prescribed sets of commands and orders. Significant quotes which reflect such conflict are:

> *I guess someone* [forensic practitioner] *coming from outside of the police or military area is likely to have a bit more of an open mind perhaps and wouldn't make as many assumptions as someone who had a police or military background... the police may have their prescribed ways of doing things...* (PP3, p. 27).

> *I think things go a little bit wrong at the end of the day where the responsibility of forensic scientists is to bring about evidence, to bring about good science, not to bring about prosecution…* (EP2, p. 29).

> *Some police think… that we have to answer according to what the investigators want, in some cases, the only reason he* [police investigator] *sent the evidence is because he thinks that this occurred and he wants something official to say and he'll quite be shocked, if you say " no it's wrong, it's not the way it has gone"* (PP4, p. 30).

Such conflict raises the issue of bias in forensic evidence at courts:

> *It is essential for the interest of justice that a body of scientists is available to individuals so that there is an alternative view that can be expressed in court counter to what might be totally wrong scientific evidence presented from the internally retained military or police forensic scientist…* (AP4, p. 16).

Conflict between the science culture and the judicial culture is mainly represented by the opposition between an empirical scientific mindset open to conjectures and refutations and a legal mindset that does not accept evidence which is subject to reasonable doubt. It is a conflict between an adversarial culture, where members of such culture are trained to seek truth through strongly advocating for their side (defendants or claimants) and an empirical cultural, where members of such culture are trained to seek truth through observation, experimentation, and validation.

The conflict between the science culture and each of the police culture and the judicial culture opens a venue for scepticism of the science identity of forensic science. A summary of the ongoing debate about the science identity of forensic science is presented in the literature review in Table- 2d (chapter 2). In this summary, a number of scholars argued that many forensic science techniques, particularly field techniques such as fingerprinting and ballistics, lack a truly scientific culture guided by protocols and backed up by research to prove reliability and validity (Giannelli, 2003; Risinger & Saks, 2003; Cole, 2006). Instead, these techniques have escaped the requirement to prove their reliability and validity as scientific applications by:

- "Overselling" their uniqueness by both forensic field experts and the police,
- Meriting judicial acceptance and unquestioned admissibility for years, where experts of these techniques (e.g. fingerprints match) are not required to prove the statistical significance of their results as opposed to those of laboratory techniques (e.g. DNA profile match).
- Claiming that the limited "litigation driven-research" studies funded and undertaken by law enforcement agencies have proven their reliability and validity, despite the many accusations that such research studies are biased to support the science basis of these techniques (Giannelli, 2003; Risinger & Saks, 2003; Cole, 2006).

Hence, the scepticism about the science nature of a number of forensic science techniques is nothing but a reflection of the conflict between the three cultures which exist within forensic science. The science culture requires proof of validity of any scientific hypothesis or conclusion. It also demands that such hypothesis or conclusion be subject to further questioning and research (refutability) consequent to its validation. On the other hand, the police and judicial cultures, once convinced by logic that a forensic technique is unique, accept such technique and impose its 'uniqueness' as a reality by admitting it into courts and basing decisions on such admissibility.

8.5.2- The Incomplete Paradigm Shift

Typically, forensic science had been an explicit police practice and profession (DAT7). Referring back to the history of development of forensic science which is presented in chapter 1, particularly to the period 1951-present (subsection-1.4.3), critical advances in forensic science techniques and applications occurred after the 1990s. These advances in forensic science came as a result of advances in the areas of molecular biology (DNA technologies), biochemistry, and analytical chemistry (Butler, 2005). Such advances have "revolutionised" forensic science from being an explicit police field to being a field catering to science technologies. A significant quote which describes such a shift is reflected in the description of PP1 of his field:

There were no civilian positions available for the firearms identification section because of the type of work, because it wasn't a scientific area at the time, it's only recently after the DNA and all new technologies that they decided well you use the microscope so it's now scientific; in fact it's not (PP1, p.4).

Based on this discussion and on thorough examination of the history of development of forensic science, Kuhn's notion of the 'paradigm shift' (1996) is adopted to explain the shift that has started taking place in forensic science since 1990. This shift is what pushed PP1 to declare that the introduction of the DNA in forensic science has introduced new responsibilities for him, where he is now required 'to swab firearms to investigate the presence of DNA' (PP1, p.4); a task which never existed before 1990.

Kuhn argued that a paradigm shift occurs as a result of a scientific revolution, where the old reigning paradigm starts shifting to a new reigning paradigm (1996). As the new paradigmatic school grows in strength and the number of advocates, the old paradigmatic school fades (Kuhn, 1996). Kuhn terms those advocates who support and defend the paradigm shift as the "avant-gardes". Adopting Kuhn's position, forensic science has been experiencing a paradigm shift from:

- an **explicitly policed paradigm** where science is a secondary context and is often applied in an ad-hoc manner (old reigning paradigm), to
- an **explicitly scientific paradigm** where science is the paramount discipline, context, and culture underpinning every application and task in the field (new reigning paradigm).

Despite the strong evidence that forensic science has been experiencing a paradigm shift since the last decade of the 20th century, Kuhn's notion cannot be simplistically applied to forensic science. Forensic science has not completely shifted and is unlikely at any given time to completely shift to an explicitly scientific empirical paradigm because such a shift contradicts:

- **The ontology of forensic science**: Forensics is first and last science pertaining to law; where the tool is scientific but the object of study and application is legal. Hence, claiming that forensic science will one day become an explicitly scientific field where the tool is scientific and the object of study is science contradicts its existence.

- **The legal standard of proof**: Forensic evidence is only accepted by a court of law if such evidence proves to be "beyond reasonable doubt". Hence, a complete shift towards an explicitly scientific paradigm makes forensic evidence and analysis subject to refutations and conjectures (Popper, 2002). Such explicit scientific nature which is refutable clashes with the 'beyond reasonable doubt' legal standard.

- **The police ownership in forensic science**: Forensic science cannot escape strong links and partnership with the police in their combined role in law enforcement. Hence, an explicit scientific mindset based on liberty in thinking, rationalism, empiricism and objectivity cannot coexist with a military mindset based on commands, orders, and prescribed practices.

Forensic science, however, cannot completely shift back to the explicitly policed paradigm. This is because the amount of science which has 'invaded' forensic science practice is now a reality acknowledged by the police departments, the legislation, and the judicial systems. This acknowledgement is reflected in the way police adjusted their practices to cater for this science reality and in the sentences issued by courts which reflect such a reality. Hence, such a reality cannot be ignored or reversed. The incomplete shift of forensic science is clearly reflected in DAT4, where the departments which administers forensic science courses distribute between scientific (e.g. chemistry and biology) and non-scientific (e.g. criminal justice and public safety) departments (Figure-4a, chapter 4).

The foregoing discussion suggests that forensic science is currently at a reigning paradigm in between the explicitly policed paradigm and the explicitly scientific paradigm. The current reigning paradigm is a "multicultural-integrated paradigm" which resulted from the integration of the science culture, which is now a reality, with the police and legal cultures, which are the typical stakeholders of forensic science. The current multicultural-integrated paradigm does not represent equal integration of each of the science, police, and judicial cultures or their respective contexts. In the current reigning paradigm the science culture might be dominant over the police and judicial cultures or vice versa. This depends on the *gardes*[50] representing and promoting each culture. In the case of forensic science, the

[50] The research adopts the term gardes, the French translation of the English word guards, to be consistent with Kuhn's adoption of the term 'Avante-Gardes'.

research suggests the presence of two groups of gardes:

- **The avant-gardes**: This group of gardes comprises the science power group. In this research, the science power group is represented by the participating forensic science educators and forensic science laboratory practitioners who are either molecular biologists or analytical chemists. The backgrounds of these participants, along with the revolutionary role of molecular biology and analytical chemistry in forensic science as reflected in its history of development, suggest that the molecular biologists and analytical chemists are mainly the avant-gardes of forensic science. These avant-gardes are representatives of the science culture and contexts in forensic science. Hence, they promote the shift of the current reigning paradigm towards the explicitly scientific paradigm.

- **The conservative-gardes**: This group comprises both the police and legal power groups. The conservative-gardes are represented in the research by the participating forensic science field practitioners, senior police advisor, and the two barristers. These gardes attempt to oppose the shift of forensic science towards an explicitly scientific paradigm because such a shift threatens their power and control over a field which has been typically managed by them for many years.

An example of how conservative-gardes oppose the scientific shift of forensic science has been presented in the preceding subsection-8.5.1. Subsection-8.5.1 emphasised the scepticism by a number of scholars about the science nature of a number of the forensic field techniques. As previously identified, forensic field positions are mainly conducted and managed by sworn police officers, who are members of the conservative-gardes group. In other words, these forensic field techniques in question are managed by the conservative-gardes. These gardes oppose in one way or another the validation of their techniques because such a validation requires scientific empiricism. Validation makes these techniques more open to scientific refutation and research. Consequently, avante-gardes of forensic science, being scientists, will be invited to contribute to such a validation process. This threatens the conservative-gardes' possession of these techniques. Therefore, conservative-gardes by opposing the validation of a number of the forensic field applications are protecting their ownership in these applications by hindering more science to migrate towards such techniques. In doing so, they are ultimately obstructing the current reigning paradigm of forensic science from further shifting towards an explicitly scientific paradigm.

Following are direct quotes which represent the stance of each of these two groups of gardes:

- Avante-Gardes:

  I actually see myself as very much a scientist first and foremost (PP6, p. 31).

- Conservative-Gardes:

  I would not say I am a scientist or a man of science… I am more of a technical officer … more of a police and judicial technical officer (PP1, p. 23).

Each of the two groups of gardes strives to promote the paradigm shift towards a paradigmatic school which reflects their mindsets, culture, and identity. The extent of the paradigm shift of forensic science towards the explicitly scientific paradigm or the explicitly policed paradigm mainly depends on the strength and the number of advocates of each paradigm. The strength of the advocates very much depends on the jurisdiction under which forensic science operates (DAT6). The number of these advocates- particularly the avante-gardes- depends in one way or another on the extent of socialisation (Bernstein, 2000) between science and uniquely forensic applications. The Science invasion of forensic science is fairly recent; hence, the forensic science techniques have not long socialised with science. In the future, the extent of socialisation may increase and consequently the number of avante-gardes may increase too. The incomplete paradigm shift of forensic science is presented in Figure-8f.

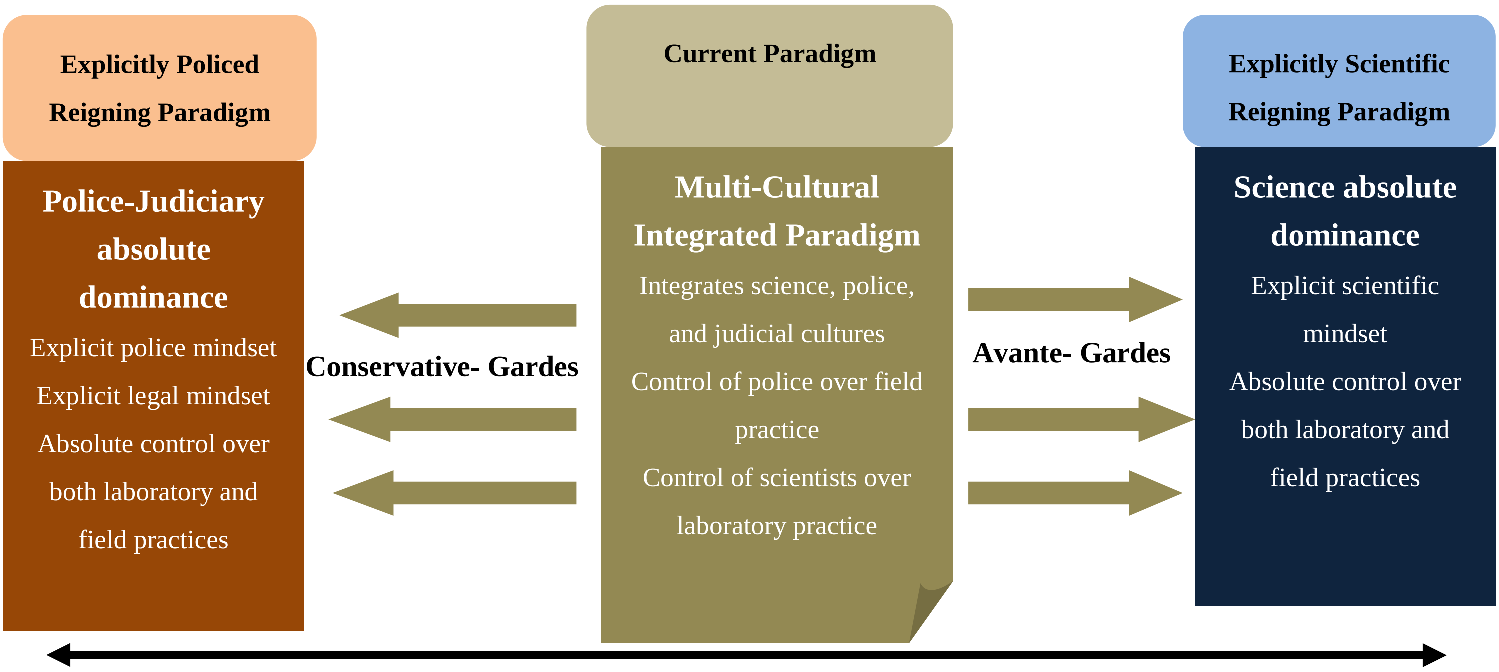


Figure-8f: The Incomplete Paradigm Shift of Forensic Science

8.5.3- The Nature of Forensic Science Identity: Summary of Findings

This section showed that the three forensic power groups identified in the previous section are representatives of the three cultures which exist within forensic science: science culture, police culture and judicial culture. Police and judicial cultures have long socialised in their role in law enforcement and in their ownership in forensic science. The science culture often conflicts with the police and judicial cultures as it requires mindsets and contexts which contradict those required by the police and judiciary to a greater extent. One of the manifestations of this conflict is the scepticism by a number of scientists about the lack of scientific validation and reliability for a number of the forensic field techniques which have been long promoted by the police and judiciary as being unique and reliable techniques.

A representation of the conflict between these three cultures is the incomplete paradigm shift of forensic science from the old explicitly policed paradigm to the new explicitly scientific paradigm. Completely shifting to any of these paradigms will promote one culture and eliminate the others; the thing which contradicts the ontology of forensic science which is merely based on the integration of all three cultures. Hence, the current reigning paradigm of forensic science is a multicultural integrated one which exists somewhere in between the old and new paradigm. The extent forensic science shifts forwards towards the new paradigm or backwards towards the old paradigm mainly depends on the strengths and number of the advocates (avante-gardes versus conservative-gardes) of each paradigm.

8.6- A Holistic Approach towards the Understanding of the Nature of Forensic Science

Scrutinising the discussions in each of sections 8.3, 8.4, and 8.5, logical connections become apparent between the findings of each section. The zones of knowledge identified in section 8.3 and their respective contexts are reflections of the way forensic power groups (section 8.4) prefer to represent such knowledge. These forensic power groups are nothing but representatives of the cultures to whom they belong (section 8.5). Through their cultures, these forensic power groups become gardes for either one of two paradigmatic schools (section 8.5). The first school favours forensic science as a set of vocational applications constituting one of the specialised roles of the police. In such a conception, this first paradigmatic school relates back to zone 2 of forensic knowledge (vocational knowledge) identified in section 8.3. The second school favours forensic science as a set of scientific inquiries and activities which need to be conducted and controlled by scientists. In such a conception, the second paradigmatic school relates back to zone 1 of forensic knowledge (science knowledge). Hence, the relation between: a) **forensic science knowledge** (represented by the identified zones of knowledge), b) **forensic science practice** (represented by the identified forensic power groups), and **forensic science identity** (represented by the identified cultures and paradigmatic schools which exist within forensic science) is a cyclic one, where each element of this relation creates implications towards the other. This cyclic relation is represented in Figure-8g.

The two cycles presented in Figure-8g represent the segmentation in forensic science knowledge, practice, and identity which are related in a multi-directional way. In other words, the **segmentation in the zones of forensic science knowledge** is a reflection of the **segmentation in forensic science practice** (field versus laboratory practice), and also a reflection of the **segmentation in forensic science identity** (policed paradigmatic school versus the scientific paradigmatic school) and vice versa. Such multi-directional relation between forensic science knowledge, practice, and identity is presented in Figure-8h. A discourse across:

a. the complexities of forensic science knowledge (multi-zones of knowledge requiring multiple-contexts),
b. the complexities of forensic science practice (segmentation in the nature of practice, unconfirmed status as a profession, and the existence of forensic power groups), and
c. the complexities of forensic science identity (multicultural conflict and incomplete paradigm shift)

reveals that forensic science is of a complex ontological nature. Forensic science uses science but is not an explicitly scientific field. A number of its field techniques are explicitly conducted by sworn police officers and follow prescribed police protocols; however, it is not an explicitly quasi-military field. Forensics is all about relating knowledge fields and forms of inquiry to legal contexts; nevertheless, it is not an explicitly legal field. Such ontological complexity is what characterises forensics and makes it unique from other disciplines.

Figure-8g: The Cyclic Relation between Forensic Science Knowledge, Practice, and Identity

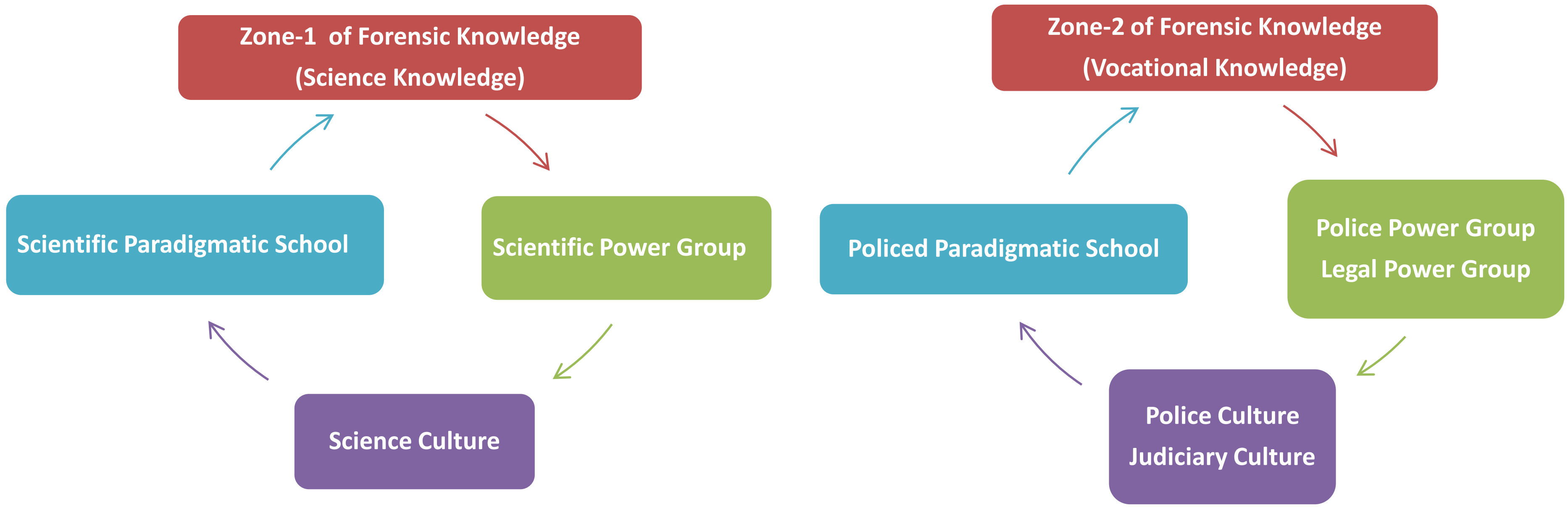
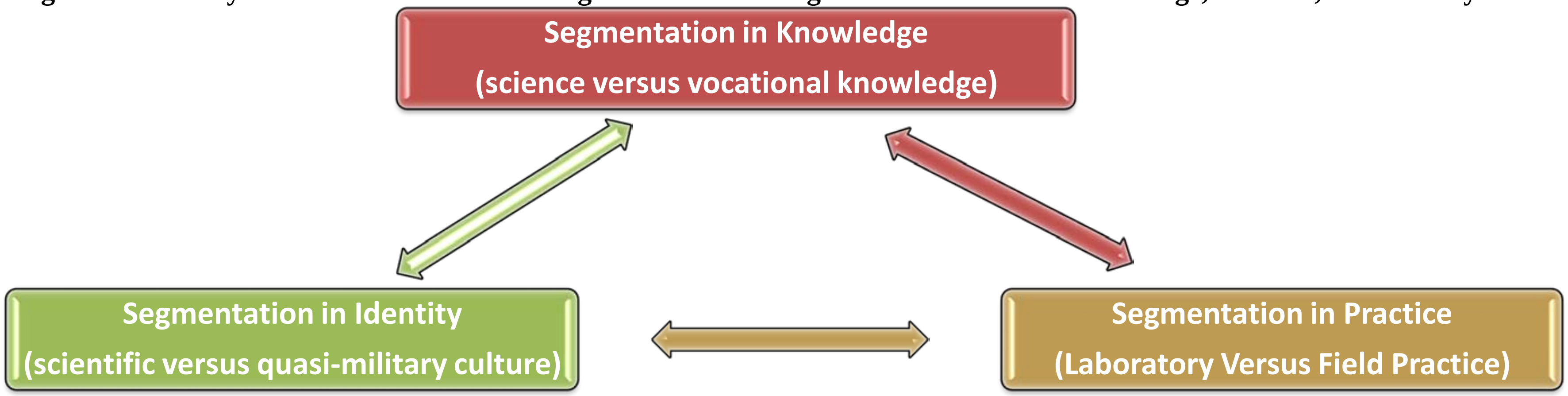


Figure-8h: The Cyclic Relation between the Segmentation Existing in Forensic Science Knowledge, Practice, and Identity



Medicine is one of the applied science fields which resemble forensic science in its pluri-disciplinarity (Lary et al., 1997) and in its fundamental reliance on physical and biological sciences (Inman & Rudin, 2000). However, medicine remains a field much more defined than forensic science in terms of its ontology and epistemology. For instance, medical education has been a focus of research and development years before forensic science emerged as an academic field (Barrows, 1996; Jonas et. al., 1989).

The ontological nature of forensic science suggests that forensics need to be perceived as a social practice rather than an isolated scientific or vocational practice. The forensic context, within which forensic practitioners are required to apply their knowledge and experiences, is nothing but a social integration between three cultures and their representative contexts: scientific, legal, and quasi-military (police). Forensic practitioners are required in the conduct of their practice to respond to the social demands of the police culture and the judicial culture. Hence, the perception of forensic science as a social practice rests on a strong foundation.

This ontological complexity cannot but be reflected as an epistemological complexity of forensic science. In its epistemology, forensic science knowledge is the result of four zones of knowledge uneasily integrated within a forensic context. The ontological and epistemological complexities of forensic science will be a challenge for any university 'forensic science' course. This will be the focus of the following section.

8.7- Education Concerns arising from the Identified Nature of Forensic Science

The complexity of forensic science in its ontology and epistemology raises critical questions about the educational form for such a field:

- The authenticity of current forensic science courses.
- The challenges which face forensic science curriculum in:
    - representing the various zones of forensic science knowledge,
    - coping with the provisional paradigm of forensic science,
    - being a discourse between the various forensic power groups,

  - coping with the segmentation existing within forensic science practice, and
  - dealing with the multicultural conflict within forensic science.
- The course features which are required to reflect the nature of knowledge, practice, and identity of such a complex field.

The research will attempt to answer these questions in the following chapter (chapter 9). By attempting to answer these questions, the research will attempt to answer the major and supplementary research questions.

8.8- Chapter Summary

This chapter started with a summary of the findings of chapters 4, 5, 6, and 7. Chapter 8 first presented discussions about the various zones of knowledge comprising forensic science knowledge. Zone 1 comprises the forensically extrinsic science knowledge. Zone 2 involves the forensically extrinsic vocational knowledge which encompasses subzones of tacit knowledge. Zone 3 is the theoretical (science) framework underpinning forensic practical applications. Within and across these three zones, critical thinking and communication skills are essential competencies. These competencies comprise zone 4 of forensic knowledge.

Chapter 8 then discussed the segmented nature of forensic science practice between laboratory practice and field practice. Such segmentation hinders forensic science from developing as a stand-alone profession. On the contrary, forensic science practice is merely a combination of various interest groups which possess a common goal in the assistance in justice administration.

The research then identified the existence of three main forensic power groups: scientific, police and legal. These power groups represent different cultures which exist and conflict within forensic science. As a result of the scientific advances which have impacted forensic science practice, forensic science is shifting from an explicitly policed paradigm towards an explicitly scientific paradigm. The police and legal power groups represent the conservative-gardes who opposes such shift. On the other hand, the scientific power group represents the avant-garde who promotes this shift. Forensic science may not completely shift forward or backwards to either of these reigning paradigms. The current reigning paradigm of forensic science is somewhere in between these two paradigms.

Finally, a discourse across the identified complexities of forensic science knowledge, practice, and identity revealed a complexity in the ontological nature of forensic science. Such ontological nature consequently leads to an epistemological complexity of forensic science. Both the ontological and epistemological nature of forensic science will be a challenge for any university forensic science course.

This chapter represented a discussion about the ontological and epistemological nature of forensic science. The following chapter will discuss the ontological and epistemological complexities which face forensic science education and how best to approach such complexities in organising a forensic science course. By doing so, the research attempts to answer the major and supplementary research questions.

Chapter 9: Discussions Relating to the Nature of Forensic Science Education

9.1- Introduction

Following the identification of epistemological and ontological features of forensic science in the previous chapter, this chapter discusses the ways through which forensic science education responds to the nature of forensic science and, in particular, the complexities of forensic science.

This chapter is organised in 8 sections. Section-9.2 summarises the findings of chapter 8 in relation to the nature of forensic science from knowledge, practice, and identity perspectives. Then it discusses the response required from any forensic education code if it is to acknowledge the nature of forensic science. Section-9.3 presents the challenges which face forensic science education. The management of these challenges is discussed in section-9.4.

Section-9.5 presents a discussion about the general features which characterise any forensic science course and associated curricular and pedagogical approaches. In section-9.6, the research presents a discussion about the current status of forensic science education. Then, the potential future of forensic science education is considered in section-9.7. Finally, section-9.8 comprises the research's reflections and suggestions for consideration in future research in the field of forensic science education.

For improving readability and ease of referring to identified themes or exemplars in chapters 4, 5, 6, and 7, this chapter adopts the same coding system implemented in chapter 8. For example, DAT4 refers to theme 4 in document analysis, while IdE2 refers to Identity Exemplar 2.

9.2- Education which Responds to the Identified Nature of Forensic Science

Chapter 8 discussed the epistemological and ontological features of forensic science from knowledge, practice, and identity perspectives. From a knowledge perspective, forensic science knowledge comprises four knowledge zones:

- science knowledge (zone 1),
- vocational knowledge (zone 2),
- underpinning theoretical framework (zone 3), and
- essential forensic competencies (zone 4).

These knowledge zones are either intrinsically (zone 2) or extrinsically (zone 1) contextualised within a forensic context. This forensic context is the result of integration of multiple-contexts: scientific, quasi-military (police), and legal.

From a practice perspective, forensic science practice is of a segmented nature which hinders the development of forensic science as a stand-alone profession. Within the forensic science field, there exist three forensic power groups: scientific, police, and legal.

From an identity perspective, forensic science has experienced, over the last two decades, an incomplete shift from an old explicitly policed paradigm towards a new explicitly scientific paradigm. The current reigning paradigm of forensic science is somewhere between the old and new paradigms. The current reigning paradigm reflects the conflict between the identified three forensic power groups. Consequently, it reflects the conflict existing between the cultures of these power groups: science, police, and judicial. The differences between these cultures, reflected in dissimilar experiences of knowledge, practice, and identity, have led to the conclusion presented at the end of chapter 8 that forensic science is of a complex ontological and epistemological nature. Table-9a summarises the findings of chapter 8.

Summary of the Findings of Chapter 8: The Nature of Forensic Science		
Knowledge Perspective	4 Zones of Knowledge	Zone 1: extrinsically contextualised science component
		Zone 2: intrinsically contextualised vocational component, where a great deal of this component is tacit knowledge within the crime scene and across various forensic science practices
		Zone 3: theoretical framework which underpins zone 2 of knowledge.
		Zone 4: critical thinking and communication skills
Practice Perspective	Segmented Practice	Segmentation between field practice and laboratory practice
		Segmentation within field practice
	Undeveloped Status as a profession	Existence of minor communities of practice makes forensic science more of a field combining various interest groups rather than a uniform profession
	Three Forensic Power Group	The scientific power group (forensic laboratory practitioners and forensic science educators who are mainly either molecular biologists or analytical chemists)
		The police power group (police and forensic field practitioners)
		The legal power group (judges, barristers, etc)
Identity Perspective	Culture Conflict	Conflict between the science culture on the one hand, and the police and judicial culture on the other.
	Incomplete Paradigmatic Shift	Multicultural-integrated paradigm existing between an explicitly policed paradigm and an explicitly scientific paradigm
		The Avante-gardes (the scientific power group that promotes the scientific paradigmatic school) versus the conservative-gardes (the police and legal power groups that advocate the police paradigmatic school).

Table-9a

In response to the nature of forensic science revealed in this research, any forensic science academic program would be expected to:

- Emphasise the four zones of forensic science knowledge,
- Respond to the segmented nature of forensic science practice,
- Acknowledge the preferences and needs of the three forensic power groups existing within forensic science,
- Deal with the cultural conflict existing within forensic science,
- Reflect the reigning paradigm of forensic science

However, a number of challenges face forensic science education in the attempt to respond to the nature of forensic science. These challenges will be the focus of the following section.

9.3- Challenges Facing Forensic Science Education

In responding to the nature of forensic science, a number of challenges (Table-9b) face forensic science education. Each of these challenges comprises two complexity components:

- an epistemological complexity component which relates to the challenge facing the organisation of forensic science knowledge, and

- an ontological complexity component which relates to the practical origin from which the epistemological complexity emerged.

	Epistemological Complexity Component	Ontological Complexity Component
Challenge 1	Emphasising Zone 1 of forensic science knowledge in one course of study is problematic	Forensic science invites various disciplines, and specialisations.
Challenge 2	Emphasising Zone 2 of forensic science knowledge is difficult, as it requires access to real practice settings to reveal the tacit knowledge.	Forensic science is of a quasi-military nature, where access to crime scenes and laboratories is restricted to members of the police in many jurisdictions.
Challenge 3	Course coordination between academia and industry stakeholders is problematic	Forensic science lacks a major community of practice; instead minor communities of practice exist and operate within forensic science.
Challenge 4	Career opportunities within forensic science are often limited.	Forensic science positions are often public positions and private investments in the industry remain limited.
Challenge 5	Emphasising the reigning paradigm of forensic science is complex.	The reigning paradigm of forensic science is the result of a conflict between forensic power groups and their respective cultures.

Table-9b

Challenge 1

Forensic science is a pluri-disciplinary field, where the forensic content is 'drawn from several subject areas to focus on a particular topic or theme' (McBrien and Brandt, 1997:55). To properly emphasise each required or invited discipline into the forensic science field 'then it will be a thirty-year course' (EP1, p.2). On the other hand emphasising the set of disciplines associated with forensic science at a 'superficial level' (EP1, p.2) will 'generate unemployable graduates... who are probably good to make comments and write little stories in the media about forensic science' (EP3, p.3) but who are not specialised in any one discipline and consequently are not qualified to work in the forensic industry.

Challenge 2

In forensic science, there exist a number of areas (KnE2) which cannot be acquired in a classroom setting. These areas require practice-based settings capable of revealing the tacit knowledge embedded within these areas in crime scenes and across various applications. For instance, students in a forensic science course covering the topic of blood pattern analysis may study the properties of blood from a biological perspective and viscosity and surface tension from a physics perspective (PP3 and PP6). However, the actual understanding of blood behaviour and the ability to perform blood pattern analysis may only be possible when these students are 'exposed to real blood' and to 'how it might be distributed' at a real crime scene (EP2, PP2, PP3, and PP6). Such a context is nearly impossible to replicate within a university setting. The problem arises from the quasi-military nature of forensic science which restricts the access of students (civilians) to crime scenes and forensic science agencies in most jurisdictions.

Challenge 3

The curricular organisation of higher education courses normally requires cooperation between course coordinators and the community of practice relevant to the profession(s) associated with these courses (Cullingford, 2004, Burgen, 1996). This cooperation addresses the knowledge base and practical components which need to be emphasised within the course to meet industry standards and requirements. For instance, in Australia, chemistry course coordinators need to cooperate and work with The Royal Australian Chemical Institute (Electronic[51], 2009), a national incorporated body concerned with the teaching and practice of chemistry in Australia. Similarly, course coordinators of Australian engineering academic programs must liaise with Engineering Australia (Electronic[52], 2009), a national forum concerned with engineering accreditation and advancement in Australia. Likewise, it would be expected that course coordinators of tertiary forensic science courses cooperate with a national body or community of practice concerned with the promotion and

[51] http://www.raci.org.au/page/RACI/The-RACI.htm, Accessed: 04/03/2010

[52] http://www.engineersaustralia.org.au/ieaust/index.cfm?0FA72E22-BBA9-F777-B6C25FC12A378FE8, Accessed: 04/03/2010

advancement of forensic science. However, forensic science does not possess a major community of practice which can contribute in setting the curricular structure of a forensic science tertiary course. Instead, minor communities of practice, independent from one another, exist for each speciality area in forensic science, organising and communicating knowledge and experiences specific to that area (e.g. fingerprinting, handwriting examination, and firearms).

Despite the fact that there exist national bodies (e.g. NIFS and AAFS[53]) which are concerned with education, training, and practice in forensic science, there is no one body which offers accreditation for the range of specialities and expertises in forensic science. In terms of education, accreditation processes of forensic science courses/programs are not available in most countries. In the few countries where accreditation of forensic academic programs is available, such accreditation is voluntary and limited. For example, in the U.S.A. in the year 2004, a commission (FEPAC) was established to offer accreditation to forensic science academic programs. However, applying for accreditation is entirely voluntary**,** where only 19 forensic science programs in the U.S.A. (out of over 155 programs) are currently accredited (Quarino & Brettell, 2009).

Challenge 4

The rapid expansion in forensic science education in terms of the number of forensic science programs offered worldwide and the number of students enrolling has not been associated with a proportional increase in forensic science positions. This led a number of participants in the semi-structured interviews to argue against forensic science tertiary courses as these courses create a problem of unemployment for a large number of graduates. The following quote (previously addressed in subsection-7.2.4, chapter 7) is of significance:

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[53] NIFS= National Institute of Forensic Science (Australia); AAFS= American Academy of Forensic Science.

There are very few people working within the profession, so how many people do you want to educate to take on few available positions? At its best you've only got like 50 vacant positions within the whole country on a yearly basis ... universities generate around 500 graduates a year, so what are you going to do about the remaining 450 graduates that aren't going to get jobs in the field that they believe they have been educated for... (EP4, p. 21).

The majority of job opportunities within forensic science continue to be within the public sector despite the various attempts at investment by the private sector in forensic science (DAT7).

Challenge 5

The current reigning paradigm is a provisional one which has resulted from an incomplete shift from an explicitly policed reigning paradigm towards an explicitly scientific reigning paradigm over the past two decades. The incomplete shift came as a response to the rapid advances in science techniques which have been successfully applied within forensic science. In the new paradigmatic context, the scientific power group (avante-gardes) has more power and control over the police and legal power groups (conservative-gardes) in a number of forensic sciences areas- specifically laboratory specialisations. However, the conflict between these power groups is ongoing. As a result, the forms of inquiry, assumptions, and procedures which might be accepted in the current reigning paradigm might not be as accepted in future paradigmatic contexts which might emerge from further paradigm shifts.

Negotiating responses to these five challenges will be the pathway to the formulation of any forensic science course. The next section will discuss various approaches which contribute to the management of these challenges.

9.4- Managing the Challenges Facing Forensic Science Education

Consequent to scrutinising the findings of the document analysis and the semi-structured interviews, this research, informed by the literature review, reports a number of approaches and strategies which contribute in managing the challenges facing forensic science education.

Managing Challenge 1

Adopting a multidisciplinary approach or a combination of curricular approaches- where multidisciplinarity is the predominant curricular approach- allows students to view forensic science through various disciplinary lenses. However, students typically use the techniques and applications of the one discipline in investigating and solving forensic science problems. This allows students to be specialists in the one discipline, whilst possessing awareness of the pluridisciplinary nature of forensic science. Multidisciplinarity may be the most appropriate curricular approach for organising a forensic science course; however, decisions about organising education are problematic (Kelly, 1999). Curriculum can be conceptualized from different perspectives reflecting the different ways people conceive human knowledge (Kelly, 1999). The following section will expand the discussion on forensic science curricula.

Managing Challenge 2

Emphasising zone 2 of forensic science knowledge in a course of study is problematic, because it requires exposure to real crime scenes, real exhibits, and real scenarios. However, this research has identified a number of approaches and strategies which can cope with such a challenge. The most appropriate approach to emphasise zone 2 of forensic science knowledge is through strong partnerships between education providers offering forensic science courses and the relevant forensic science agencies or law enforcement agencies. Document analysis revealed that a number of forensic science courses possessed strong partnerships with their local forensic science agencies. For instance, the education institute offering FOR-556 had within its premises a forensic DNA laboratory holding DNA profiles which were part of a national DNA database. A second example is the education institute offering FOR-558. This institute had agreements in place which allowed its senior students to accompany law enforcement officers on crime scenes and assist in a number of preliminary tasks (e.g. photographing and diagramming). However, the majority of jurisdictions do not facilitate partnerships which provide access by outsiders to crime scenes and forensic science facilities. The research, therefore, has identified two options to manage challenge 2:

- Some forensic science courses (subsection-4.5.2, chapter 4) arranged for a number of its subjects and curricular activities to be delivered by current forensic science practitioners. Such an arrangement might not be as efficient in emphasising zone 2 of forensic science knowledge. However, it does at least emphasise the theoretical framework (zone 3) underpinning this zone through practitioners' reflections on their knowledge and experiences.

- Forensic science, in a number of courses, was mainly emphasised through research projects between the university and the local forensic science laboratory. In these research projects (mainly honours and master's projects), the majority of the research activities were conducted within the university's facilities. However, a supervisor from the forensic science laboratory was appointed- in addition to an academic supervisor- to guide each research student. This appointment benefited the students by facilitating exposure to practising forensic personnel and up-to-date equipment in the forensic science laboratory.

Managing Challenge 3

Offering forensic science courses which hold general titles such as "bachelor of science in forensic science" may not be an authentic response to the expanding public interest in the field. This is because these titles create the false impression that the courses cover all the forensic science areas and hence graduate multi-tasked forensic individuals as seen on the "CSI show". Instead, a coordinator of a forensic science course needs to add a specific title to the course which truly reflects the content of this course and the minor forensic community of practice to which the course relates. For instance, a course which focuses on forensic chemistry and relates to forensic chemistry laboratories would be expected to have the title “forensic chemistry course”. On the other hand, a course which focuses on crime scene examination and relates to the crime scene examiners’ community of practice would be expected to have the title of “crime scene examination course” or “crime scene investigation course”. These specific titles make forensic science courses genuine and contribute to the formation of realistic expectations for enrolling students.

Managing Challenge 4

The rapid expansion in forensic science courses and students’ enrolments in such courses create a challenge for forensic science education, as career opportunities within the forensic science industry are generally limited. This situation has pushed a number of forensic science courses to organise a “fall-back position” within their curricula (e.g. FOR-754 and FOR-766, subsection-4.5.3, chapter 4). These courses cater for a specialised science component in addition to the forensic science component. For instance, a number of courses incorporated a specialised chemistry component in addition to the forensic science component. Graduates of these courses were accredited as chemists by the relevant national committees. Hence, these students had a range of career opportunities as chemists in a number of industries (e.g. the pharmaceutical industry and food industry) in addition to career opportunities in forensic chemistry laboratories.

Managing Challenge 5

The provisional reigning paradigm of forensic science is the result of a complex interaction between the interests and preferences of the avante-gardes (scientific power group) and the conservative-gardes (police and legal power groups). Hence, any forensic science academic program would be expected to manage such uneasy interaction through a “**Pinarian conversation**”. The research adopts the term “Pinarian” in reference to Pinar’s notion of the curriculum as being a complex conversation between various groups and stakeholders (2004). This Pinarian conversation needs to take into consideration the needs and demands of each group of gardes. It also needs to be a reflection of the jurisdiction (DAT6) which regulates the practice and the power of these groups. For instance, in certain jurisdictions the scientific power group (avante-gardes) may have more power and control over the forensic science practice than the police power group (conservative-gardes) or vice versa. Therefore, a Pinarian conversation is expected to not only be a reflection of the interests, expectations, and preferences of each group of gardes, but also be an expression of a critical balance of power and control between these groups.

9.5- Towards Organising a Forensic Science Course

The question “do we need forensic science education in academia?” is a complex question which cannot be simply answered by a “yes” or a “no”. It is highly uncommon in social sciences and education to just adopt discrete answers, categories, or options. Education and the way knowledge is created, set, and transmitted are even less able to provide the certainty with which natural science is associated.

In this section, the research discusses the features of an “authentic” forensic science course and the curricular and pedagogical approaches which emphasise such features. By “authentic”, the research refers to those courses which emphasise and respond to the nature of forensic science. These authentic forensic science courses favour the “yes” answer to the question on whether or not we require forensic science education in academia.

9.5.1- Features of a Forensic Science Course

Section 9.2 argued that any forensic science course needs to respond to the nature of forensic science. A forensic science course can do so by emphasising the epistemological and ontological attributes of forensic science:

- the four zones of forensic science knowledge
- the segmented nature of forensic science practice
- the preferences and needs of the three forensic power groups
- the cultural conflict existing within forensic science
- the reigning paradigm of forensic science

The knowledge, practice, and identity exemplars, which were presented respectively in Table- 8b, Table-8c, and Table-8d in chapter 8, may be adopted as general features for any forensic science course as such exemplars reflect the nature of forensic science. Table-9c presents each of the forensic science exemplars, which will be now considered as general features of a forensic science course, and the corresponding emphasised attribute.

	Features of a Forensic Science Course	Emphasised Attribute of the Nature of Forensic Science
Knowledge Exemplars	**Feature 1: KnE1**	The scientific component exemplar stresses both zone 1 and zone 3 of forensic science knowledge and reflects the science power group.
	Feature 2: KnE2	The vocational component exemplar stresses zone 2 of forensic science knowledge and reflects the police power group.
	Feature 3: KnE3	The legal component exemplar contributes to the understanding of the forensic context and relates to the legal power group.
	Feature 4: KnE4	Essential forensic capabilities stresses zone 4 of forensic science knowledge.
Practice Exemplars	**Feature 5: PrE1**	The forensic sensibility exemplar responds to zone 2 of forensic science knowledge and contributes to the revealing the tacit knowledge within the crime scene and across forensic practices.
	Feature 6: PrE2	The practice complexities exemplar promotes zone 4 of forensic science knowledge.
	Feature 7: PrE3	The critical conduct exemplar helps express the skills incorporated within zone 4 of forensic science knowledge.
	Feature 8: PrE4	This exemplar emphasises the segmented nature of forensic science practice.

Identity Exemplars	**Feature 9: IdE1**	The complex identity exemplar is a reflection of the cultural conflict within forensic science and the consequent conflict between the respective paradigmatic schools.
	Feature 10: IdE2	The policing context exemplar is a representation of the police power group and the police culture.
	Feature 11: IdE3	The legal context exemplar is a representation of the legal power group and the judicial culture.
	Feature 12: IdE4	The high-risk ethical exemplar is a reflection of the high-risk ethical nature of forensic science.
	Feature 13: IdE5	This exemplar is a reflection of the conflict between the various forensic power groups and an ultimate reflection of the conflict between the two paradigmatic schools existing within forensic science.

Table-9c

Subsequent to the elaboration of the general features of a forensic science course, organising a forensic science course (curriculum) and delivering it (pedagogy) remain a challenge. This challenge will be the focus of the following subsections.

9.5.2- Curricular Approach Organising Forensic Science Education

Document analysis revealed that the two main curricular approaches adopted by the selected forensic science courses were the multidisciplinary and the interdisciplinary approaches in an approximate ratio of 1:2 (subsection-4.5.1, chapter 4). In other words, the interdisciplinary curricular approach was adopted twice as much as the multidisciplinary one in the selected forensic science courses. On the other hand, analysis of semi-structured interviews revealed that the majority of the participants argued for the multidisciplinary curricular approach (subsection-5.2.3, chapter 5). The major arguments associated with each of multidisciplinarity and interdisciplinarity are presented in the following two paragraphs.

Arguments Favouring Multidisciplinarity

The multidisciplinary approach draws on a number of disciplines but ultimately adopts the one discipline to perform the task (Geisler, 2002). It represents education in depth (Bernstein, 2000). Hence, this approach reflects the nature of forensic science, because forensic practitioners need to be aware of the variety of disciplines incorporated within forensic science; however, they need to be specialists in only the one field (the first group participants and participating laboratory practitioners, subsection 5.2.3, chapter 5). Employment in the forensic laboratory area requires specialised science backgrounds which can best be emphasised through a multidisciplinary approach. The following quote from EP2 (previously emphasised in chapter 5) is of significance:

> *They* [Students] *have to understand the full context which means that they have to understand all of these bits of disciplines; however, they have to be specialists in only one discipline* (p.3)… *Lab directors want people with strong science backgrounds* (p.4).

Moreover, a multidisciplinary approach by allowing students to become specialists in the one field (e.g. chemistry or biology) facilitates the fall-back positions in case students could not find a job within the forensic industry (FOR-754 and FOR-766, subsection-4.5.3, chapter 4).

Arguments favouring interdisciplinarity

The interdisciplinary approach facilitates integration and communication between disciplines (Diller, 1990) in order to 'examine a central theme, topic, issue, problem, or work' (Jacobs, 1989:5). It represents education in breadth (Bernstein, 2000). Hence, this approach responds to the nature of a number of forensic field applications (e.g. blood pattern analysis), where forensic practitioners draw on a number of disciplines to perform the one task (the second group participants and AP2, subsection-5.2.3, chapter 5). The following quote (previously addressed in chapter 5) is of significance:

> *The knowledge of blood stain pattern analysis incorporates physics, biology, chemistry, and maths… so it certainly draws upon a number of disciplines* (PP2, p.9).

Multidisciplinarity versus Interdisciplinarity

This uncertainty in favouring one curricular approach over the other may best be approached from Pinar's notion of curriculum theory (2004). According to Pinar, curriculum theory is 'a complex field of scholarly inquiry within the broad field of education' which strives to understand curriculum across the various academic disciplines. Hence, forensic science educators, forensic science practitioners, police officers, and members of the judiciary would be expected to actively collaborate in order to define a forensic science curriculum which reflects their needs, negotiate their concerns, and respond to the complex nature of the field. By doing so, such curriculum would be reflecting the current reigning paradigm of forensic science and the two conflicting paradigmatic schools within the reigning paradigm.

Based on these discussions, this research suggests that the adoption of more than one curricular approach may assist in reflecting the nature of forensic science and in responding to the various needs and concerns of various forensic science stakeholders. Drake and Burns, for example, argue that an educator should not completely rely on the one curricular approach in course delivery (2004). For instance, a course adopting a discipline-based curriculum should allow for a fragment of integration or cross-disciplinarity as there are skills (e.g. problem solving and critical thinking) which may best be acquired through integration. Similarly, a course adopting an integrated-based curriculum should emphasise some disciplinarity as there are some theories and core knowledge (e.g. fundamental theories in biology and chemistry) which may only be emphasised through disciplinarity (Drake & Burns, 2004). Hence, the research recommends the following in relation to forensic science education:

- Courses which relate to forensic laboratory practice need to adopt an overall multidisciplinary approach. Such approach will allow students to view forensic science through the lenses of the various disciplines but ultimately specialise in the one science discipline (zone 1 of forensic science knowledge). For instance, a forensic chemistry course would be expected to stress the various disciplines invited into forensic science practice, but ultimately it has to adopt chemistry as the main discipline. However, the overall multidisciplinary approach has to cater for interdisciplinarity to emphasise knowledge for those areas which require the integration of a number of disciplines to perform the one task (zone 2 of forensic science knowledge). A minor interdisciplinary approach may be emphasised through specific subjects within the curriculum, projects, and placements.

- Courses which relate to forensic field practice need to adopt an overall interdisciplinary approach. Such approach will facilitate the integration of various disciplines in order to perform field tasks such as crime scene examination and blood pattern analysis (zone 2 of forensic science knowledge). However, the overall interdisciplinary approach has to emphasise certain disciplinarity in a number of subjects or activities. This disciplinarity is necessary to stress the theoretical framework underpinning most field applications (zone 3 of forensic science knowledge).

The research, having proposed the above recommendations, does acknowledge that curricular decisions remain the outcome of the Pinarian conversation expected to take place between the forensic course coordinator and the gardes (forensic power groups) of each of the two conflicting paradigmatic schools within forensic science. This conversation is affected by each individual jurisdiction under which forensic science practitioners operate (DAT6 and IdT3). This topic will be further explored in subsection-9.5.4 following discussions about pedagogical strategies in forensic science education which will be the focus of the following subsection.

9.5.3- Towards a Pedagogical Approach in Forensic Science Education

The identified four zones of forensic science knowledge demand both formal and informal learning settings. Whilst zone 1 and zone 3 require more formal learning settings, zone 2 demands more informal ones. Zone 4 may best be approached by a combination of both settings. In this section, the research discusses the various teaching and learning strategies and their relation to various zones of forensic science knowledge.

<u>Formal Learning Setting</u>

Emphasising theoretical knowledge requires learning settings which are ‘reliable’, ‘fall into clear-cut hierarchy, and subject divisions’, and are mainly transmitted as ‘structured information’, all of which are notions of formal learning settings (Becket & Hager, 2001:131). Formal learning setting comprises a number of pedagogies which are of significance to forensic science education. In this respect, the research has considered lecture-based learning (LBL) and problem-based learning (PBL) as pedagogical practices which are very effective in forensic science education.

LBL is argued to be the most effective teaching and learning strategy in emphasising theoretical content and knowledge (Ekeler, 1994). Hence, LBL might be very effective in emphasising the scientific theories embedded within zone 1 and zone 3 of forensic science knowledge. These theories are critical for: a) the understanding of the theoretical framework underpinning most of forensic science tasks, b) backing up forensic evidence and arguments with a solid logical basis, c) and approaching the more complicated forensic science cases.

PBL is defined as a teaching and learning strategy focused around ‘the investigation and resolution of messy, real-world problems’ (Torp & Sage, 1998:14). In PBL, students are exposed to complex problems where they work in groups coordinated by the teacher in order to: identify a problem, explore the knowledge base and competencies required to solve the problem, and finally solve the problem (Humelo-Silver, 2004). Forensic science in its ontology is nothing but a field focused on solving problems which face the judicial system as a result of a criminal act, an offence, or a civil dispute. Hence, there is strong suggestion that PBL is a very effective strategy for forensic science education as it directly relates to the ontology of this field. In the same context, Beckett and Hager (2002) and Savin-Baden (2003) argue that PBL promises to be one of the most efficient pedagogical strategies in emphasising critical thinking, because it promotes the "knowing how" forms of knowledge. Hence, PBL may be very effective in emphasising zone 4 of forensic science knowledge, particularly critical thinking.

Medicine was the first discipline to accommodate PBL and apply it (Jonas et al. 1989). In this respect, the academic forensic medicine program offered by the University of Hong Kong may be a very useful benchmark case study for forensic science education. The University of Hong Kong describes PBL as the most adequate teaching and learning strategy in medical education (2008), for such a strategy is able to:

- cope with the future demands in medicine including the revolutionary development of diagnostic technologies, therapeutic procedures, and surgical procedures, and
- deal with real-life medical situations.

Within the forensic medicine program offered by the University of Hong Kong, PBL has proved its efficiency in graduating students who know how to learn, what to learn, and how to overcome any gaps or deficiencies in their knowledge base (Beh, 2009). Forensic science resembles medicine, in general, and is very much related to forensic medicine, in particular. Hence, the strategy (PBL) which has already proven to be efficient in medical education and forensic medical education is very likely to be as efficient in forensic science education.

Informal Teaching and Learning Setting

Whilst many areas of forensic science demand a formal learning setting, there exist a number of forensic areas which cannot be approached but through an informal practice-based setting. These areas are mainly field areas and constitute the knowledge base of zone 2 of forensic science knowledge.

Informal practice-based learning has been argued by Beckett and Hager to be a pedagogical strategy which favours organic and holistic, collaborative and collegial, contextualised, and experienced-based learning (2001). Hence, informal-practice based learning is indispensible to forensic science education because:

- An organic and holistic learning approach is critical in the creation of a forensic science sensibility (PrE1) and a holistic awareness of the nature of forensic science practice.

- A contextualised teaching and learning strategy is essential to forensic science, particularly in forensically contextualising the extrinsic zones of knowledge (zone 1) and in emphasising the already contextualised intrinsic zones of knowledge (zone 2).

- Collaborative and collegial learning is critical to forensic science as the complex nature of the crime scene in many instances requires collaborative and collegial work between personnel of various disciplines and backgrounds (PrT2), and

- Experience-based learning is indispensable to forensic science as there was consensus amongst all participants in the semi-structured interviews on the importance of experience in building-up expertise within forensic science practice (subsection-5.3.5, chapter 5). In this respect, PP2, when asked how he learned and acquired the majority of his forensic science competencies in crime scene examination, answered:

> *As far as how did you learn that, the answer is by experience, but not through text books, it's by going out and living that job* (PP2, p. 8).

Practice-based learning also caters for learning through observation or mentoring, a teaching and learning strategy which is critical in cultivating the tacit knowledge embedded within the crime scene and across various forensic science practices. Through mentoring, the more experienced and knowledgeable forensic science practitioners assist the mentees in acquiring forensic science competencies, expressing the tacit knowledge embedded within the practice (zone 2 of forensic science knowledge), and developing their critical thinking (zone 4 of forensic science knowledge). Learning through observation or mentoring has been emphasised by the majority of the participants in the semi-structured interviews (subsection-5.3.4, chapter 5). Mentoring may take place at the crime scene, in the laboratory, and in courts where the mentees develop their communication skills (zone 4 of forensic science knowledge).

Pedagogical Decisions Regarding Forensic Science Education

Based on the above discussions, the research recommends a cluster of teaching and learning practices which can emphasise the four zones of forensic science knowledge. In other words, the research recommends adopting a pedagogical approach which is the result of the integration of both formal and informal teaching and learning practices. Such an approach is capable of emphasising:

- Zone 1: LBL (emphasising theoretical knowledge) and PBL (forensically contextualising the emphasised theories).

- Zone 2: Practice-based learning (acquiring practical knowledge through mentoring and revealing the tacit knowledge) and PBL (stressing the contextualised forensic knowledge).

- Zone 3: LBL (emphasising the underpinning theoretical framework for most forensic tasks).

- Zone 4: Practice-based learning and PBL (promoting critical thinking and communication skills).

Similar to the decisions regarding the curriculum of a forensic science course, the final decision on the pedagogy of a forensic science course needs to be the outcome of a complex inquiry (Pinar, 2004) into the needs, expectations, and concerns of the various social groups (Bernstein, 2000) existing within forensic science: the scientific power group, the police power group, and the legal power group. Further exploration on this topic will be presented in the following subsection.

9.5.4- Decisions Regarding Forensic Science Education

Forensic science is a new emerging field whose paradigmatic status is still unconfirmed. Bernstein's notion of social groups, as being social domains possessing power and control over their fields and over the knowledge of such fields, contribute in the understanding of the conflict (hidden or apparent) between the avante-gardes and the conservative-gardes within the forensic science field. Hence, the paradigm shift within forensic science is far from over. The unconfirmed paradigmatic status of forensic science makes education and curricular decisions about forensic science uncertain.

Pinar's notion of the curriculum as the site where 'generations struggle to define themselves' (Pinar, 1999:366) provides a relevant and critical reading of forensic science education. In this context, a forensic science curriculum may be seen as a site where:

- each of the avante-gardes and conservative-gardes strive to define themselves, reflect their interests and preferences, and maintain their authority and ownership,
- the scientific culture (based on empiricism and refutations) conflicts with the quasi-military culture (based on orders and prescribed procedures) and judicial culture (based on adversarial system and beyond reasonable doubt standards),
- each of the explicitly policed paradigm and the explicitly scientific paradigm struggle against one another.

Based on these discussions and a careful consideration of the unconfirmed reigning paradigm of forensic science and the associated complexities, this research suggests that any education or curricular decision related to forensic science needs to be the outcome of:

- a complex Pinarian conversation between the explicitly policed paradigm and the explicitly scientific paradigm

- a complex Pinarian discourse between the scientific mindset on the one hand, and the police and legal mindsets on the other,
- a complex Pinarian negotiation of each of the avante-gardes and conservative-grades requirements, preferences, interests, and concerns,
- a complex Pinarian reflection of students needs, expectations, and concerns.

Such complex Pinarian conversation, discourse, negotiation, and reflection are nothing but a Pinarian mapping of the complexities and uncertainties within forensic science. Hence, the research views this Pinarian process as a function of a number of factors:

- The nature of the forensic science course: whether a course is relating to forensic field or laboratory practice,

- The outcome of the Pinarian conversation expected between a forensic course coordinator and the advocates of each of the two conflicting paradigmatic schools within forensic science:

  - Forensic laboratory practitioners and forensic science educators (avante-gardes) on the one hand, and

  - Forensic field practitioners, senior police advisors, and senior judicial advisors (conservative-gardes) on the other.

  This Pinarian conversation is expected to be not only a negotiation of the interests, expectations, and preferences of each group of gardes, but also a critical reflection of the balance of power and control between these two groups.

- The jurisdiction in place which directly impacts both:

  - the distribution of power and control between the avante-gardes and the conservative-gardes, where the preferences of the more powerful group are expected to be reflected to a greater extent in a Pinarian conversation, and

- the shape, structure, and extent of partnership and associated teaching and learning practices between the university and local enforcement agency.

- Students' needs and capabilities, and
- The university's facilities, whether or not an educational institute can provide:
    - specific equipment and technologies of relevance to forensic science (e.g. DNA profiling technologies and chromatography laboratory) and
    - practical applications and activities of significance to forensic science. (e.g. mock-up court presentations and mock-up crime scenes).

9.5.5- Section Summary

In this section, the thesis argued that the forensic science's knowledge, practice, and identity exemplars may be adopted as general features of a forensic science course. These features respond to the nature of forensic science and cope with the challenges facing forensic science education. This chapter then discussed the education decisions which need to be adopted in regards to organising (curriculum) and delivering (pedagogy) forensic science education in a course of study. The conclusion of this study is a recommendation that any forensic science course be organised by a combination of curricular approaches which facilitate a cluster of three teaching and learning practices (LBL, PBL, and practice-based learning). These three pedagogical practices are essential in emphasising the four zones of forensic science knowledge. However, this research has acknowledged that the final education decisions relating to organising and delivering a forensic science course need to be negotiated between the forensic course coordinator and the professional groups to which the course relate. This Pinarian negotiation and conversation needs to be a critical reflection of the balance of power and control between the avante-gardes and the conservative-gardes. It also needs to be a reflection of students' needs, concerns, and expectations.

The discussions in this section together with the previous sections will help define the characteristics of an authentic forensic science course. The following section will present a discussion about authentic versus inauthentic investments in forensic science education within academia. This discussion will result in a critical description of the current status of forensic science education.

9.6- The Current Status of Forensic Science Education

Forensic science has developed remarkably and become a high profile field over the past two decades. This development and prominence are result of scientific and technological advances in forensic science, increased reliance of law enforcement agencies and judicial systems on forensic science services, and the huge media focus on forensic science topics and themes. Consequently, forensic science has experienced a dramatic expansion in terms of the number of academic forensic science programs offered worldwide and the number of students enrolling in these programs. However, the dramatic expansion in forensic science education has attracted both authentic and inauthentic investments in such education.

Based on the discussions in sections 9.2, 9.3, 9.4 and 9.5, the research considers an investment in forensic science education to be authentic when a course can emphasise the four zones of forensic science knowledge, reflect the ontological and epistemological nature of forensic science, and manage the complexities which face forensic science education. On the other hand, the research considers an investment in forensic science to be inauthentic when a course fails to properly emphasise the four zones of forensic science knowledge, is unable to manage forensic science complexities, and is run in isolation from industry stakeholders (the forensic science power groups).

The failure of many courses (inauthentic courses) to:

- Truly reflect the nature of forensic science (reliance on media focus to oversell traditional science courses by adding the adjective “forensic” to the course’s title) and

- Set strong links with the forensic power groups in order to create career opportunities within the forensic science industry for their graduates

Has prompted a number of the participants in the semi-structured interviews to aggressively argue against forensic science tertiary education, particularly education at the undergraduate level (see subsection-7.2.4, chapter 7):

> *Employability is the real acid-test... forensic science is an area where it's totally crazy to build the course in isolation, in vacuum from the forensic industry because you will go nowhere* (EP3, p.28).

Scrutinising the findings of document analysis, authenticity in forensic science education was clearly reflected in:

- The courses which revealed major contributions of forensic science practitioners in course delivery (e.g. FOR-766),
- The courses which emphasised strong relationship with forensic science and law enforcement agencies (e.g. FOR-556 received direct funding from law enforcement agencies and FOR-558 had a strong partnership in place which allowed senior forensic science students to accompany forensic practitioners to real crime scenes), and
- The courses which warned prospective students on their websites from unrealistic expectations of forensic science due to the "CSI effect" (e.g. FOR-551 and FOR-706).

On the other hand, inauthentic forensic science courses were easily identified from:

- An overselling attitude for a number of courses which mainly relied on emphasising the "CSI Show" (e.g. FOR-358).
- Running the course in isolation from law enforcement agencies or in absence of significant contribution from forensic science practitioners (e.g. FOR-560).

Cross comparison between document analysis and the analysis of the semi-structured interviews revealed that undergraduate forensic science courses are more subject to the criticism of being inauthentic than non-award courses and postgraduate courses. This is explained by the fact that the majority of the non-award forensic science courses are directed towards police officers and personnel already employed within the forensic science sector. Hence, these courses are courses set for a specific aim. Postgraduate forensic science courses are offered to students who had already acquired knowledge mainly in one of the science streams. Hence, students are not locked within one career opportunity.

Whilst there are stronger arguments and suggestions for forensic science education to be offered as non-award degrees- if partnered with a law enforcement agency- and as postgraduate degrees, there exist a number of undergraduate forensic science courses which proved to be authentic in their content, delivery, connections with industry stakeholders, and true reflection of the nature of forensic science.

As for the relationship between authenticity and the nature of the administering department, document analysis showed that there is no correlation between the course being authentic and the nature of the department administering such a course. However, the uncertainty in relation to the identity of the administering department of forensic science courses is nothing but a reflection of the unconfirmed status of the reigning paradigm of forensic science.

9.7- The Future of Forensic Science Education

A great deal of the uncertainty and randomness that forensic science currently experiences in academia is a reflection of:

- The unconfirmed status of the reigning paradigm of forensic science,
- The clash between the two paradigmatic schools existing within the reigning paradigm, and

- The conflict between the three forensic power groups in defending their preferences and interests in forensic science, and ultimately their power and control over forensic science.

With advances in scientific applications and technologies, more of these applications and technologies are expected to be applied within forensic science, particularly within forensic field practices (Robertson, 2010). In such a scenario, the conservative-gardes, who often come from non-scientific backgrounds, will have no option but to allow for more socialisation between science and forensic field applications. This socialisation suggests there may be value in the adoption of Maxwell’s stance in making the ‘metaphysical’ assumptions (uniqueness, validity, and reliability) many forensic field applications possess more explicit and subject to critical scrutiny and criticism (2005, 2006). By doing so, such assumptions, which long lived the unquestionable admissibility by courts but the scepticism of the scientific communities, will proceed in the hierarchical manner Maxwell described in his aim-oriented empiricism (AOE).

Proceeding through the AOE hierarchy will allow these forensic science techniques to become less implicit, more truthful, and hence more “scientific”. Such a process is very likely to offer a means of resolving the crisis of identity many forensic science field techniques are currently experiencing. By doing so, a more defined identity of forensic science might be emerging.

The result of the increased socialisation between science and forensic field applications will be an increase in the number and the power of the avante-gardes at the expense of the conservative-gardes. This will ultimately lead to:

- more power and control for aim-oriented forensic empiricism, where many of the forensic science field techniques proceed through the AOE hierarchy towards a more defined scientific status and identity,
- additional paradigm shifts towards the explicitly scientific paradigm,

- more homogenisation of forensic science as a field of practice, where the science culture (e.g. scientific backgrounds, mindsets, and approaches of practitioners) becomes predominant over the police and legal cultures,
- more homogenisation of forensic science as a field of study which might be reflected in more certainty in the identity of forensic science as a stand-alone academic field (e.g. more certainty in the level of offer of forensic science education and the identity of the administering department of forensic science courses),
- less restrictions for academics to access forensic science practice settings, and
- stronger partnerships between academia on the one hand, and law enforcement agencies managing forensic science services on the other.

In such a potential paradigm shift of forensic science towards the explicitly scientific reigning paradigm, authentic forensic science courses are expected to maintain their sustainability and benefit from stronger partnerships and more flexible arrangements with the relevant law enforcement agencies. These courses are also expected to benefit from research opportunities in areas (e.g. fingerprinting, handwriting examination, ballistics, and firearms) which heretofore have been restricted to members of the police and military. On the other hand, inauthentic forensic science courses are expected to either:

- benefit from the new partnerships and research opportunities and hence become authentic, or
- fade as the media focus- mainly relied on for marketing - would have moved onto the next interesting topic following astronomy (the popular Apollo Space Program and related shows in the 1970's and 1980's) and forensic science (the popular CSI show and related shows in the 1990's and 2000's).

Through a careful consideration of the literature review, the findings of the document analysis, the findings of the analysis of semi-structured interviews, and the discussions about the nature of forensic science presented in chapter 8, this study proposes that there is a directly proportional relationship between the authenticity of forensic science courses and the sustainability of these courses. In other words, the more authentic forensic science courses are, the more sustainable they are. The converse may also be true!

9.8- Reflections and Suggestions

In this section, reflections on the research journey, reflections on findings limitations, and suggestions for future research opportunities are presented.

9.8.1- Reflections on the Research Journey

Investigating and researching forensic science education was a challenge for this study mainly because publications in this area are scarce. However, the adoption of a document analysis compensated for the scarcity in the literature about forensic science education by generating an understanding of the current status of forensic science education. Document analysis also identified "grey areas" which were awaiting clarification by semi-structured interviews with the major stakeholders of forensic science: forensic science educators, forensic science practitioners, and members of associated professions. The inclusion of the three groups of participants was critical in approaching the nature of forensic science and forensic science education through different lenses. This triangulation practice was also essential in identifying the various social groups existing within forensic science and in representing their preferences in organising forensic science education.

The adoption of a two-stage methodological approach (document analysis and semi-structured interviews) elongated the research journey. However, it was critical for generating insights into the nature of forensic science and the consecutive nature of forensic science education.

9.8.2- The Limitations of the Findings

The findings of this study face three limitations:

- The research, confronted by the broad landscape of forensic science which incorporates a variety of disciplines (e.g. pathology, psychology, archaeology, entomology, computing, etc), limited the field's definition to criminalistics (forensic chemistry, forensic biology, and uniquely forensic forms of inquiry).

- The research limited semi-structured interviews to Australian participants only, although this limitation is partial as most participants possessed international experiences (e.g. studied aboard and/or held a forensic overseas position). In addition, the sample size of the interviews (14 participants) might pose a limitation towards the generalisation of the research findings.

- The research is limited by the fact that it did not include students' opinions in investigating forensic science education. However, this limitation is mitigated by the fact that a number of the participants in the semi-structured interviews were either recent graduates (PP6), or were enrolled in a tertiary forensic science course (PP5) at the time the interviews were conducted.

Expanding the scope of the research to minimise these limitations would have demanded time and resources which were beyond the capacity of the research. However, these limitations will create opportunities for future research in forensic science education. This possibility will be the focus of the following subsection.

9.8.3- Suggestions for Future Research

The research limitations discussed in the previous subsection create opportunities for further research in forensic science education. Each limitation by itself is an opportunity for future research in this area. The limitation resulting from restricting the working definition of forensic science urges research to be conducted in areas such as forensic psychology education, forensic archaeology education, and forensic computing education. Results emerging from the potential research may be cross-compared with that emerging from this study to create a holistic reading of forensic science education.

The limitation emerging from the exclusion of international interviewees suggests the need for more research to be undertaken with international forensic science personnel. Such research would enrich the findings related to forensic science education and supports the validity and reliability of these findings.

The final limitation results from the exclusion of students' perceptions in the research methodology. The fact that students are major stakeholders in the process of teaching and learning urges the conduct of more research projects focused on students' perceptions of forensic science education. For instance, further research opportunities may focus on:

- The expectations of forensic science students of their course of study;
- The evaluation of recent forensic science graduates of their study experience;
- Feedback from forensic science students in relation to the adoption of various pedagogical strategies (PBL versus LBL) to emphasise forensic science knowledge base and competencies.

A research opportunity which significantly expands the research findings of this thesis emerges from a critical integration of Maxwell's view of science as aim-oriented empiricism with the notions of Bernstein, Kuhn, and Pinar. Maxwell's notion of AOE raises questions about "whose aims orient forensic science empiricism? Are they the aims of the legal practitioners, police forces, and/or scientists?" Such questions are mainly based on Maxwell's AOE notion, but they ultimately invite and critically integrate with:

- **Bernstein's notion of power and control**: How can the "aims" of various power groups orient forensic science empiricism into the one direction or the other?

- **Kuhn's notion of the paradigm shift**: How can a paradigm shift within forensic science be promoted by certain "aims" (avante-gardes) and be opposed by other aims (conservative-gardes)?

- **Pinar's notion of the curriculum as a conversation**: How can a conversation between various groups and stakeholders map various aims and orient forensic science empiricism?

These questions create a landscape for further research about the politics of forensic science education. Such research, if conducted, will have significant implications for forensic science education in terms of its policymaking and organising and on the politics of education in general.

In summary, any future research in the area of forensic science education will be of benefit as it will provide new insights into a new emerging academic area, where little is known or published.

9.9- Chapter Summary

This chapter discussed the nature of forensic science education following the discussions about the ontological and epistemological nature of forensic science presented in chapter 8. In this chapter, the research identified the five major challenges which face forensic science education and discussed various approaches to manage those challenges. The research also discussed how the identified knowledge exemplars (chapter 5), practice exemplars (chapter 6), and identity exemplars (chapter 7) constitute general features of a forensic science course. These features emphasise the four zones of forensic science knowledge, reflect the nature of forensic science practice, and reflect the identity of the forensic science field (characterised by cultural conflict and the incomplete paradigm shift within forensic science). The research then discussed the curricular and pedagogical frameworks required to emphasise these features in a course of study. In this regard, the research argued that any education decision relating to the organisation and delivery of a forensic science course needs to be the outcome of a Pinarian conversation between forensic science course coordinators and the power groups that exist within forensic science.

This study concluded that in forensic science, there exist both authentic and inauthentic forensic science courses. Whilst the authentic forensic science courses emphasise the nature of forensic science and respond to its ontological and epistemological complexities, the inauthentic forensic science courses fail to do so.

The research anticipated that the future of forensic science will experience migration of more science into forensic field practices. This migration will result in further shifts of the current reigning paradigm towards the explicitly scientific reigning paradigm. This will create research opportunities in forensic field areas and will facilitate stronger and more flexible partnerships between education providers and law enforcement agencies. These anticipated changes in forensic science will support the sustainability of authentic forensic science courses on the one hand, whilst challenging that of inauthentic forensic science courses.

This chapter presented the researcher’s reflections on the research journey, research limitations, and future research opportunities. Any further research in the area of forensic science education is important and beneficial as it adds up to the literature of this new emerging academic field.

In conclusion, forensic science is a field of contention between various contexts, cultures, and mindsets (scientific versus police/judicial). It is a field of an unconfirmed reigning paradigm but confirmed complexities associated with the paradigm. Hence, education decisions related to forensic science may best be approached through a Pinarian conversation which maps the various complexities within the field and negotiate the various interests, preferences, and concerns of various forensic social groups and forensic science students.

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List of Appendices

Appendix A

Disciplines Incorporated Within Forensic Science

<u>Pure Sciences</u>

a. Chemistry: The majority of forensic chemistry work is the identification and analysis of controlled substances, explosives, unknown drugs, corrosives and poisons by undergoing presumptive testing using chemical reagents at a primary stage (Genege, 2002) and more advanced analytical techniques for definitive identification such as gas chromatography, mass spectrometry, infrared, UV, etc (Bell, 2008).

b. Biological Sciences: Forensic Biology covers many biological areas some of which are decay process, body fluids, human tissues, wounds, bacteria, viruses, fungi, vertebrates and invertebrates as forensic indicators and evidence, in addition to genetics and molecular biology techniques: DNA profiling and applications (Gunn, 2008; Butler, 2005). A major area in forensic biology is forensic botany. Forensic botany mainly investigates various types of plants (e.g. poisonous, cannabis), parts of plants (fibres, fragments, and pieces), wood, and stomach and gastric contents (Robertson, 2004).

c. Maths: Many basic and sophisticated maths principles, formulas and applications are involved in the forensic science field, most important of which is statistics. Statistics is used in the forensic science field to examine the probability of uncertainty of an evidence and the 'weight' of this evidence in front of the court (Lucy ,2005).

d. Physics: Physics is involved in many areas of forensic analysis among these are projectiles (e.g. bullets trajectory), vehicle collisions, physics of explosions, electricity, electronics, fluid mechanics, and blood stain patterns analysis (e.g. blood viscosity) (University of Ontario Institute of Technology, Electronic[54]). Physics is also used to identify tiny amounts of paints, drugs, and fibres found at crime scenes through infrared spectromicroscopy (Wilkinson et al., 2002).

<u>Forensic Applications of Science</u>

a. Forensic Pathology: It is the use of medicine in matters related to law. It involves the determination of cause and manner of a suspicious or an unknown death which often includes autopsy or post-mortem examination of the human body (Houck & Siege, 2006). Forensic pathologists also deal with living cases such as testing and determining alcohol intoxication and examining victims of rape and sexual assault (Eckert, 1997).

[54] http://www.science.uoit.ca/index.php?option=com_content&task=view&id=214&Itemid=228

b. Toxicology: It is mainly the conductance of chemical testing and analysis of body fluids and tissues in order to identify the presence (if any), quantity and effect of a drug, poison, or any toxic substance (Houck & Siege, 2006).
c. Forensic Nursing: Forensic nursing is usually involved in crime scene investigations and in crisis centres such as rape centres (Camenson, 2001).
d. Forensic Anthropology: It is the identification of human remains through the examination of the skeleton to provide evidence in a court of law. Some of the applications of forensic anthropology are to discover the post-mortem interval and suggest the age, sex, descent, and the physical features of a deceased (Plat, 2003). Forensic anthropology can be of substantial assistance in cases of mass disasters for example, aviation disasters and mass burials in the cases of human rights violations (Katzenberg & Saunders, 2008).
e. Forensic Archaeology: It is the application of archaeological methods and techniques to a legal investigation (Ferllini & Wecht, 2002). Some of the applications that forensic archaeology undermines are the search for unlocated crime scene, identification of grave locations, scene assessments, excavation and recovery, scene reconstruction, cemeteries examination, and identification of coffin hardware and remains (Chicora, 2003)
f. Forensic Entomology: It is the 'branch of forensic science in which information about insects is used to draw conclusions when investigating legal cases relating to both humans and wildlife' (Gennard, 2007:1). The first generation of the flies (larvae) which appears on a dead body, provides a 'biological clock' that determines when death took place even after two or more weeks from the discovery of the body (Greenberg & Kunich, 2002:3).
g. Forensic Odontology: It is the examination and analysis of dental evidence in matters pertaining to law. For example, some of the many issues forensic odontology deals with is the identification and analysis of bite marks and the identification of unknown human remains through the examination and analysis of dental records (BAFO, 2002)
h. Forensic Geology: It is the determination of the origin or the place from which geological materials (e.g. rocks, soil, and sand) have been removed, once found on a crime scene, inside a stolen car, at the back of a shoe and the like (Eckert, 1997).
i. Forensic Computing: Forensic Computing involves crimes and offences in which computers have been used (Camenson, 2001) and therefore requires the systematic examining of computer hard disks, diskettes, tapes, etc, in order to provide convincing evidence that is admissible by court (Vacca, 2002).

j. Forensic Engineering: It is mainly the use of engineering principles, techniques and methods to investigate cases which involve failure analysis of materials and constructions. It also involves reconstruction of traffic accidents as well (Houck & Siege, 2006).
k. Forensic Accounting: It is the application of accounting techniques to matters pertaining to criminal and civil law such as corporate investigations, insurance claim, bankruptcy, check forgery, check kiting, credit card fraud, contested divorce settlements, tax fraud, etc (Bell, 2004).
l. Forensic Economics: It is the estimation of the 'value of the victim's present and future lost income resulting from wrongful injury or death.' (Camenson, 2001: 5)
m. Forensic Psychiatry & psychology: It is mainly the studying and analysis of the mental state of an accused or an offender at the time he/she committed an offence in order to determine his/ her awareness of what had happened and mental interpretation of the act committed, thus, determining insanity, if at all, and liability for the offence committed (Houck & Siege, 2006). This field also involves the analysis of behaviour personality (psychograms) which may offer a profile of an offender to law enforcement officers (Eckert, 1997).

Uniquely forensic forms of inquiry

a. Crime Scene Investigation: It is a structured and systematic observation and search of a crime scene. A crime scene examiner is responsible for the documentation, photography, and sketching of a scene. The examiner is also responsible for the identification of any exhibits (e.g. tissues, traces, prints, and impressions) in the crime scene and the collection of such exhibits for processing at various forensic laboratories (White, 2004; Bell, 2004).
b. Fingerprinting: A fingerprint is an 'impression of the friction ridges of all or any part of the finger' (SWGFAST, 2003:9). Fingerprints are both permanent and unique in that no two fingerprints are alike even for identical twins, despite the fact that identical twins have same DNA. Therefore, fingerprinting has been one of the most powerful tools of identification (Tilstone et al., 2006).
c. Footwear and Shoeprints: Footwear impressions are created as a result of the deformation of the substrate when footwear is impressed against the ground and this might result in the transfer of trace materials, residue, and dregs from the shoe to the substrate. Foot impressions are important evidence as they connect a criminal to a crime scene (Bodziak, 2000).
d. Questioned Document Examination: It involves the: a) study and investigation of documents to determine the facts about their preparation and history, b) recognition of non-genuineness, c) analysis of inks, papers and other substances that comprise documents, d) reveal of additions and substitutions, and

restoration of erased and obliterated writing (Kelly, 2006:10). Questioned documents might include wills, deeds, medical records, tax records, time sheets, contracts, loan agreements, election petitions, checks, and anonymous letters (White, 2004).

e. Tool Mark Examination: It is the examination of 'striation marking' made by various objects such as screwdrivers, knives, pliers, crowbars in wood, putty and other media that must be forced to gain entry to property and seldom used to frighten a sexual assault or murder victim. The examination of tool marks can provide valuable trace evidence that would lead to identification (Kiely, 2005).

f. Photography and Imaging: Forensic digital imaging and photography requires some basic understanding of the human visual system for its use and development (Blitzer & Jacobia, 2002). Forensic digital imaging and photography is used in criminal cases for the recording of crime scenes: exact location & surroundings and for the recording of evidence: marks and prints on documents, glass, wood and other surfaces. It is also used in extracting evidence from surveillance videotapes and enhancing the image of latent fingerprint for the ease of comparison and identification. Digital imaging is also used in civil cases, for example, cases of personal injury as a result of manufacturer liability, where images are used to show the failures in product manufacture. With advances in technology, digital imaging nowadays facilitates computer-based identification and classification of objects, prints, trace marks and tool marks (Russ, 2001).

g. Firearms and Ballistics Examination: It is the 'study of bullets, cartridge cases, and other materials associated with the firearms as physical evidence' (Bell, 2004:136). Forensic experts in firearms work on the identification of fired bullets or other ammunition components as having been fired from a specific firearm (White, 2004). The role of the firearms and ballistic examiner is to identify: (1) what takes place interiorly inside the firearm (powders, ignition, pressure, etc), (2) what happens exteriorly after the bullet leaves the barrel (trajectory of the bullet from muzzle exit to impact), and (3) what happens to the impacted object or surface (human, paper, glass, etc) at instance of impact and in the following minutes (Rinker,1999). The examiner then attempts to relate the fired bullets to a particular firearm (Bell, 2004).

h. Arson: Forensic investigation in arson cases studies the behaviour of fire, identifies the cause and origin of this fire and identifies the type of this fire: electrical fire, automobile fire, insurance fraud fires, etc (Bouguard, 2004)

i. Explosives: It involves the study of the properties and classification of various types of explosives and explosives detection using various means (Yinon, 1999).

University/ Country	**Appendix B** Typology including 16 universities offering a forensic science degree
TYP-101 USA	**Level of Offer**: Undergraduate
	Course Title(s): Bachelor of science in forensic chemistry
	Administering Department: School of chemistry and environmental sciences
	Syllabus: Heavy chemistry component with minor criminal justice and biology components
	Place of Practice: Through laboratory practicals, seminars, and projects
	Career Opportunities: Laboratory forensic chemist and crime scene investigators
TYP-102 Australia	**Level of Offer**: Non-award TAFE degree
	Course Title(s): Certificate IV in forensic science
	Administering Department: Department of public safety and sciences
	Syllabus: forensic subjects of vocational nature (e.g. fingerprinting, physical evidence, crime scene processing, etc)
	Place of Practice: Syllabus is delivered by current forensic science practitioners
	Career Opportunities: Course intended to provide further training for personnel already employed as forensic practitioners, law enforcement officers, and security officers. The course also provides entry level employment opportunities in the forensic science industry
TYP-103 USA	**Level of Offer**: Postgraduate
	Course Title(s): Master's in Forensic Science
	Administering Department: Department of chemistry and biochemistry
	Syllabus: Interdisciplinary curriculum bridging between chemistry, biology and forensic science subjects
	Place of Practice: Course is delivered in formal partnership between the university, law enforcement agencies, and government laboratories and corporations.
	Career Opportunities: local, state, and national forensic laboratories
TYP-104 UK	**Level of Offer**: Both undergraduate and postgraduate
	Course Title(s): Undergraduate: Bachelor of Science in: forensic science, chemistry and forensic science Postgraduate: Master's and PhD by Research in Forensic Chemistry
	Administering Department: Department of chemical and forensic sciences
	Syllabus: Undergraduate: heavy chemistry component with a light biology and forensics component Postgraduate: Research mainly using chemistry to resolve a problem or investigate an issue of interest to forensic science
	Place of Practice: Laboratory demonstrations, pre-lab briefings, one-to-one teaching in the laboratory, and workshops; 1 year work placement in a forensic science agency or relevant laboratory
	Career Opportunities: forensic laboratory technicians, crime scene investigators, and chemists.

TYP-105 USA	**Level of Offer**: Undergraduate **Course Title(s)**: Bachelor of science in forensic science **Administering Department**: Department of criminal justice **Syllabus**: Balance between science, forensic science, and law subjects **Place of Practice**: close association with state police department and state forensic medical laboratory; students are exposed to mock courtroom and real forensic laboratories **Career Opportunities**: Employment in criminal justice and forensic science fields
TYP-106 UK	**Level of Offer**: Undergraduate **Course Title(s)**: Bachelor of forensic science **Administering Department**: School of biological sciences **Syllabus**: heavy biology component, with light forensic and chemistry components **Place of Practice**: 1 year of work placement between the 2nd and 3rd years in one of the forensic centres or law enforcement agencies. **Career Opportunities**: both public and private forensic laboratories
TYP-107 Australia	**Level of Offer**: Undergraduate **Course Title(s)**: Bachelor of forensics in forensic biology **Administering Department**: School of biological science and biotechnology **Syllabus**: molecular biology, molecular genetics, analytical chemistry, and minor emphasis on forensic botany, pathology, and anthropology **Place of Practice**: within university through laboratory practicals and workshops where practitioners in the field participate **Career Opportunities**: crime scene officer, government health departments, analytical laboratories, hospitals, research organisations, medical research centres, agriculture departments, food processing companies, or pharmaceutical industry
TYP-108 Canada	**Level of Offer**: Undergraduate **Course Title(s)**: Bachelor of science in forensic chemistry **Administering Department**: Stand-alone forensic science department **Syllabus**: Multidisciplinary syllabus mainly focused on chemistry and draws on a number of disciplines: biology, physics, mathematics, law, and principles and practices of forensic science laboratories **Place of Practice**: curriculum includes lectures from police personal and visits to forensic agencies **Career Opportunities**: Forensic technicians, policing, and teaching
TYP-109 Switzerland	**Level of Offer**: Both Undergraduate and Postgraduate **Course Title(s)**: Undergraduate: Bachelor of science in forensic science, Postgraduate: Masters of Science in forensic science, and PhD in forensic science. **Administering Department**: School of Criminal Justice (Faculty of law and criminal sciences) **Syllabus**: Bachelor: first year of study focuses on the theoretical basics of chemistry, basic sciences and criminal

	sciences. In the second year, the syllabus requires the consolidation of basic scientific subjects (statistics, organic chemistry) and is extended to the field of law. Starting the third year, the teaching in forensic sciences becomes specialised: the interpretation of and the approach to criminal analysis form the basis of new transversal subjects. Master's: In the first year, transversal courses cover common areas of the forensic sciences. The specialised teaching given allows the students to deepen their knowledge in the various areas and techniques of identification: detection of traces, fingerprinting, forensic genetics, analysis and interpretation of biometric data, firearms and munitions, ballistics, etc. In the second year, the students put their knowledge into practice by working on fictional cases covering several types of traces. They also complete a diploma assignment consisting of a personal research project. PhD: PhD is undertaken as a research degree using mainly chemistry to investigate a topic of interest/correlation to forensic science
	Place of Practice: mock court trials, moot crime scenes, practicals at laboratory.
	Career Opportunities: Forensic laboratories, Scientific police services, forensic medical laboratories, and public opportunities which require identification skills.
TYP-110 Australia	**Level of Offer**: Undergraduate
	Course Title(s): Bachelor of forensic science- Forensic Chemistry or Forensic Biology
	Administering Department: School of life and environmental sciences
	Syllabus: The course combines studies in biology, chemistry, biochemical and chemical analysis, statistical analysis and molecular biology. Students will also undertake studies in criminology, including the examination and interpretation of evidence and courtroom skills. Students undertaking the forensic chemistry concentration will cover more chemistry subjects, whilst those undertaking forensic biology concentration will cover more biology and molecular biology subjects.
	Place of Practice: In addition to laboratory practicals included within the curriculum, the course has extensive industry links with local and Australian forensic organisations, and features guest lecturers and site visits in collaboration with leading forensic organisations.
	Career Opportunities: career opportunities exist in forensics, insurance investigation, risk analysis, research science, education, in government institutions and in chemical, food and pharmaceutical industries
TYP-111 USA	**Level of Offer**: Non-award TAFE degree
	Course Title(s): Crime scene certificate/ Associate in science degree in crime scene technology
	Administering Department: School of professional and technical studies
	Syllabus: Mainly forensic subjects of vocational nature (e.g. fingerprinting, physical evidence, etc)
	Place of Practice: Program is delivered through academics, law enforcement officers, and forensic practitioners
	Career Opportunities: Employment in various fields related to crime scene investigation
	Level of Offer: Postgraduate
	Course Title(s): Master of Science in forensic science

TYP-112 UK	**Administering Department**: multi-departmental course **Syllabus**: syllabus provides strong foundation in science together with an understanding of the logic and workings of the legal system; program is a combination of course work and research **Place of Practice**: through laboratory practicals and research component. **Career Opportunities**: Local, state, federal, and private crime laboratories; consulting and investigation positions
TYP-113 USA	**Level of Offer**: Non-award TAFE degree **Course Title(s)**: Certificate in forensic science **Administering Department**: Administration of justice **Syllabus**: combination of law and forensic subjects **Place of Practice**: syllabus is delivered by both academics and practitioners in the field; **Career Opportunities**: public jobs and field forensic positions
TYP-114 UK	**Level of Offer**: Undergraduate **Course Title(s)**: Bachelor of science degree in forensic sciences **Administering Department**: school of natural sciences and mathematics **Syllabus**: interdisciplinary with a minor component of chemistry and biology and intensive maths, physics, and forensics subjects. **Place of Practice**: delivered by both academics and practitioners in the field; through senior year practice-based internship in a forensic science agency/centre **Career Opportunities**: careers in forensic science
TYP-115 USA	**Level of Offer**: Postgraduate **Course Title(s)**: Masters of Forensic Sciences **Administering Department**: Department of professional studies **Syllabus**: Interdisciplinary curriculum which emphasises forensic science subjects with law subjects **Place of Practice**: Through supervised graduation research project **Career Opportunities**: course designed for law enforcement, laboratory personnel, attorneys, investigators and other professionals seeking to upgrade their existing skills; course opens opportunities for individuals in pursuing a career in the forensic sciences, law, law enforcement, private and government laboratories, jails and corrections, and medical examiner's officer.
TYP-116 USA	**Level of Offer**: Non-award TAFE degree **Course Title(s)**: Certificate in advanced forensic investigation **Administering Department**: Administration of Justice **Syllabus**: Mainly vocational forensic subjects **Place of Practice**: Subjects delivered by academics and current forensic practitioners **Career Opportunities**: Course intended to provide further training for personnel already employed as private investigators, law enforcement officers, and security officers.

Appendix C

Conceptual attributes of knowledge, practice, and identity in forensic science that may be suggested by 15 selected curricula of institutes that offer forensic science programs or degrees

Curriculum Attribute	Category of Description	Possible Indicators of Conceptual Attribute(s)
Knowledge	a. Curriculum nature and organisation	a. Course nature, duration, and entry requirements and curriculum nature (e.g. collection code v.s. integrated code curriculum).
	b. Knowledge fields in course	b. Extent to which the course is 'forensic': nature of subjects (e.g. pure/applied chemistry, pure/applied biology, mathematics, physics, law, fingerprinting, crime scenes, ballistics, arson).
	c. Teaching pedagogies and curricular activities adopted in course delivery	c. Teaching approaches such seminars, PBL, tutorials, moot court-room presentation, etc.
	d. Assessment practices	d. Theory vs. practical; place of field work
	e. Connections between knowledge fields and curriculum components	e. Extent subject nature and content relate to/ contribute in course aims/ objectives achievement.
Practice	a. Place of forensic practice in course	a. Specific subject content, statement about 'field work'
	b. Extent of practice	b. Level of specification
	c. Pedagogical practice	c. Teaching strategies which acknowledge forensic practice
	d. Practitioner participation in course delivery	d. Indications from subject(s) related to on 'crime scene' education.
Identity	a. Course location	a. University organisational unit (e.g. Institute of Forensic Science, Institute of Criminology, Department of Chemistry, and Faculty of Sciences)
	b. Course type	b. Undergraduate degree or postgraduate program
	c. Relation to other courses	c. Stand alone course or Strand of mainstream science program
	d. Evidence of course outcomes	d. Statement of possible graduate employment
	e. Relationship to external authorities	e. Professional association, police and legal bodies

Appendix D

Interview Questions for the First Group Participants (Educators)

The purpose of this interview today, is to explore your perceptions on how the 'Curriculum and Pedagogy of Forensic Science Courses shall/might Reflect the Practice, Knowledge and Identity of the Forensic Science Field'.

To start with, I would like to advise that there are no right or wrong answers. It is simply your opinions, concepts, and perceptions we are seeking. We want to explore your own personal view. From time to time, I will be playing devil's advocate to get your opinions on some of the issues being explored – this will just be to get the discussion going to help explore your views. Please don't feel that you have to agree with me or not – I just would like to help to understand your perceptions on the topics we will be discussing.

This interview will be carried out in compliance with all the requirements of confidentiality and the code of ethics as set by the ethics committee of Victoria University of Technology. With your permission, this interview will be audio recorded. However, your participation in the research will be confidential and all data collected in the interviews will be de-identified prior to analysis and the publication of any research findings. Data from this interview will be coded in such a way that your identity remains anonymous. Storing of names and code lists will be separate from questionnaires. Access to data for data analysis purposes will be limited to the principal investigator and the research student only. All data will be stored in a locked filing cabinet at the conclusion of the research.

1) To start with, may you please describe yourself as a forensic science educator in terms of your qualifications, experience, specialisation, and everyday activities?
2) I would like you to remember one of the most recent experiences that you had have in your forensic science teaching practice.

a. What lesson(s) were you teaching? In which chapter?
b. May you please describe when and where did this most recent lesson take place?
c. Could you please describe this most recent experience?
d. Do you teach all the lessons of your subject at one place or at a variety of places? (e.g. classroom, laboratory, law agency, forensic science external)
e. What are the competencies that you were aiming the students to acquire from this lesson?
f. What are the knowledge bases that the students should have acquired at the end of this lesson/ chapter?
g. What are the teaching method(s) and/or strategy that you followed to teach this lesson/ chapter?

3) Generally speaking, I would like you to think in general about your everyday teaching in forensic science.
   a. What are the teaching method(s) and/or strategy that you follow in your approach to teaching? I am particularly interested in the ways in which you introduce the forensic dimension into you teaching.
   b. What are the curricular activities that you find essential in the course delivery?
   c. How does your course engage students in the practices of forensic scientists?
   d. What are the knowledge bases that your students should have acquired at graduation in both your subject and the course as a whole? What are the perceptions held by the forensic science profession of the knowledge understanding and skills of your graduates?
   e. What are the competencies that your students should have acquired at graduation in both your subject and the course as a whole?
   f. How do you make sure that the teaching method(s)/ strategy that you approached would complement with the desirable outcome of acquired knowledge bases and competencies?

4) Now I would like to show you 2 reports of the document analysis (Appendix K) that has been performed in this research on 78 educational providers from various English-Speaking countries.
    a. What are the first impression(s) that you draw from reading these two reports?
    b. How do you comment on Report (A)?
    c. How do you comment on Report (B)?

    d. Given your understanding of the practices of forensic science, what do you think are the important factors to be considered when a university is deciding the faculty location for a forensic science course?
    e. What levels of offer (non-award program, undergraduate, postgraduate, or undergraduate and postgraduate) would you expect an educational provider to run? Why do you say so?
    f. From your perception, how might a forensic science program/ course be structured to reflect the daily practices of forensic science? What knowledge fields should comprise the subjects in the course structure?
    g. What other curricular activities would you expect to see?

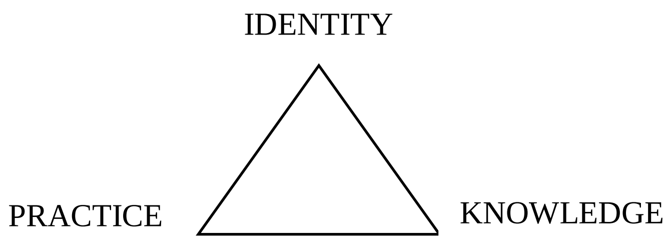
5) To finish up this interview, I would like to ask you few more questions. From your perception(s), what are the factor(s) that shape the identity of forensic science? Now I would like to list some factors in front of you, then I would like to ask you few questions about the influence (if any) of these factors in shaping the identity of forensic science. The factors are: <u>Forensic science practitioners</u>, <u>forensic science educators</u>, <u>politicians</u>, <u>society</u>, <u>judicial system</u>, <u>police</u>, <u>media</u>, and <u>technology</u>?

    a. Which of these factors (if any) might influence the identity, image, and/or shape of forensic science?
    b. Is this influence a major or a minor one? Why do you say so? (Repeat question after each selected factor).

c. Is there any other factor(s) that is not listed and may impact forensic science identity in one way or the other? If so what are these factors?

6) Some courses offered worldwide, are exclusively offered to members of police or military and the others are not. From your perception what are the advantages and disadvantages of the involvement of civilians in forensic science?

7) Finally, couple of more questions. I would like you to consider the following triangle:



The first vertex represents the contributing knowledge bases in forensic science, from pure sciences, applied sciences, arts, and uniquely forensic pieces of knowledge. The second vertex represents the daily practice of forensic science: on crime scene, in the lab and in court. The third vertex represents the way in which forensic scientists, forensic science educators and associate professionals perceive the field, i.e. how they perceive the identity of forensic science.

a. How can you describe such a triangle, emphasising on the relationship between its three vertices.
b. Would you like to adjust anything in this triangle? If yes, what is the thing(s) that you would like to adjust? And why?
c. If you can imagine a picture, where you are standing in this picture along with lecturers from other fields, such as engineering, medical sciences, physics and law. What characterises you as a forensic science educator from other educators? What makes you similar to other educators in other disciplines? Why do you say so?
d. Just simply, in your own words what is forensic science from your perception?

Appendix E

Interview Questions for the Second Group Participants (Practitioners)

The purpose of this interview today, is to explore your perceptions on how the 'Curriculum and Pedagogy of Forensic Science Courses shall/might Reflect the Practice, Knowledge and Identity of the Forensic Science Field'.

To start with, I would like to advise that there are no right or wrong answers. It is simply your opinions, concepts, and perceptions we are seeking. We want to explore your own personal view. From time to time, I will be playing devil's advocate to get your opinions on some of the issues being explored – this will just be to get the discussion going to help explore your views. Please don't feel that you have to agree with me or not – I just would like to help to understand your perceptions on the topics we will be discussing.

This interview will be carried out in compliance with all the requirements of confidentiality and the code of ethics as set by the ethics committee of Victoria University of Technology. With your permission, this interview will be audio recorded. However, your participation in the research will be confidential and all data collected in the interviews will be de-identified prior to analysis and the publication of any research findings. Data from this interview will be coded in such a way that your identity remains anonymous. Storing of names and code lists will be separate from questionnaires. Access to data for data analysis purposes will be limited to the principal investigator and the research student only. All data will be stored in a locked filing cabinet at the conclusion of the research.

This study is not meant to judge you nor the level of education and/ or practice of any forensic science institute, centre, or program. Your participation is absolutely voluntary. You can withdraw your participation at any stage. You have all the right to refuse to answer any question or part of a question for no reason. At no stage are you required to continue the interview if you do not feel like to do so.

1) To start with, I would be interested in hearing about how you describe yourself as a forensic science practitioner in terms of your everyday activities, experience and specialisation? For example, what do you find yourself saying to members of associated professions e.g. the police and lawyers?

2) Without disclosing any confidences, I would like you to remember one of the most recent experiences in your every-day forensic science practice. This experience may be on a crime scene, in the lab or in the court.
   a. Please describe when and where did this experience take place?
   b. Please describe this most recent experience?
   c. Where you working by yourself or accompanied by other(s)?
   d. What are the competencies that you used in performing your task?
   e. Where and how did you acquire these competencies?
   f. What are the knowledge bases that assisted you in performing the task?
   g. Where and how did you acquire this knowledge base?

3) Generally speaking, I would like you to think in general about your everyday practice in the forensic science field.
   a. What are the most common forensic science activities that you are required to undertake? And what are the most important activities?
   b. What are the competencies and knowledge base you use in your everyday practice?
   c. Where and how did you acquire these competencies/ knowledge base?
   d. If you received formal forensic science education, please tell me how the forensic science course prepared / did not prepare you for practice in the field.

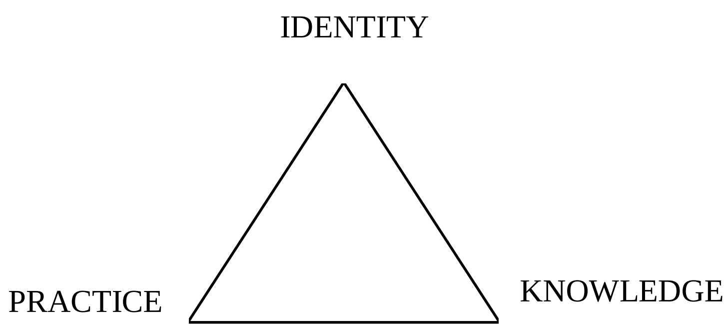
4) Now I would like to show you 2 reports of the document analysis (Appendix K) that has been performed in this research on 78 educational providers from various English-Speaking countries.
   a. What are the first impression(s) that you draw from reading these two reports?

b. How do you comment on Report (A)?
c. How do you comment on Report (B)?
d. Given your understanding of the practices of forensic science, what do you think are the important factors to be considered when a university is deciding the faculty location for a forensic science course?
e. What levels of offer (non-award program, undergraduate, postgraduate, or undergraduate and postgraduate) would you expect an educational provider to run? Why do you say so?
f. From your perception, how might a forensic science program/ course be structured to reflect the daily practices of forensic science? What knowledge fields should comprise the subjects in the course structure?
g. What other curricular activities would you expect to see?

5) From your perception(s), what are the factor(s) that shape the identity of forensic science? Consider for example the influence of: <u>Forensic science practitioners</u>, <u>forensic science educators</u>, <u>politicians</u>, <u>society</u>, <u>judicial system</u>, <u>police</u>, <u>media</u>, and <u>technology</u>?
   a. Which of these (if any) might influence the perception, image, and/or shape of forensic science?
   b. Is the influence a major or a minor one? Why do you say so? (Repeat question after each selected factor).
   c. Are there any other factors not listed which may impact forensic science identity in one way or the other? If so what are they? What is their impact?

6) Some courses offered worldwide, are exclusively offered to members of police or military and the others are not. From your perception what are the advantages and disadvantages of the involvement of civilians in forensic science?

7) Finally, consider the following triangle and focus on its three vertices:



The first vertex represents the contributing knowledge bases in forensic science, from pure sciences, applied sciences, arts, and uniquely forensic pieces of knowledge. The second vertex represents the daily practice of forensic science: on crime scene, in the lab and in court. The third vertex represents the way in which forensic scientists, forensic science educators and associate professionals perceive the field, i.e. how they perceive the identity of forensic science.

a. How can you describe such a triangle emphasising on the relationship between its three vertices.

b. Would you like to adjust anything in this triangle? If yes, what is the thing(s) that you would like to adjust? And why?

c. If you can imagine a picture, where you are standing in this picture along with practitioners from other fields, such as engineers, medical doctors and environmental scientists. What differentiates you from other practitioners? What makes you similar to other practitioners? Why do you say so?

d. Just simply, in your own words what is forensic science from your perception?

Appendix F

Interview Questions for the Third Group Participants
(Members of Associated Professions)

The purpose of this interview today, is to explore your perceptions on how the 'Curriculum and Pedagogy of Forensic Science Courses shall/might Reflect the Practice, Knowledge and Identity of the Forensic Science Field'.

To start with, I would like to advise that there are no right or wrong answers. It is simply your opinions, concepts, and perceptions we are seeking. We want to explore your own personal view. From time to time, I will be playing devil's advocate to get your opinions on some of the issues being explored – this will just be to get the discussion going to help explore your views. Please don't feel that you have to agree with me or not – I just would like to help to understand your perceptions on the topics we will be discussing.

This interview will be carried out in compliance with all the requirements of confidentiality and the code of ethics as set by the ethics committee of Victoria University of Technology. With your permission, this interview will be audio recorded. However, your participation in the research will be confidential and all data collected in the interviews will be de-identified prior to analysis and the publication of any research findings. Data from this interview will be coded in such a way that your identity remains anonymous. Storing of names and code lists will be separate from questionnaires. Access to data for data analysis purposes will be limited to the principal investigator and the research student only. All data will be stored in a locked filing cabinet at the conclusion of the research.

This study is not meant to judge you nor the level of education and/ or practice of any forensic science institute, centre, or program. Your participation is absolutely voluntary. You can withdraw your participation at any stage. You have all the right to refuse to answer any question or part of a question for no reason. At no stage are you required to continue the interview if you do not feel like to do so.

1) To start with, may you please describe yourself in terms of your qualifications, experience, specialisation, and everyday activities?
2) I would like you to think about your profession based on your experience and everyday practice.
   a. How is your profession related to forensic science?
   b. Would you describe the relationship of your profession to forensic science as a competing, complementing or conflicting relationship? Why do you say so?
   c. I would like you to remember any recent experience when you had to deal directly or indirectly with a forensic scientist? May you please describe when and where did this experience take place.
   d. Can you describe this experience? For example, without disclosing confidences, what was the nature of the conversations you had with a forensic scientist?
   e. What are the competencies and/or practice did the forensic scientist display in front of you?
   f. What impressions did you have about forensic science after having this experience? Have you had a different impression before this experience? Please comment.

3) Generally speaking, I would like you to think in general about forensic science. What are your expectations of forensic scientists? What are the competencies and knowledge bases that you expect to see in a forensic science practitioner? What strategies do you need to adopt in dealing with forensic scientists so that your work is successful? What problems do you encounter in your work with forensic scientists?

4) Now I would like to show you 2 reports of the document analysis (Appendix K) that has been performed in this research on 78 educational providers from various English-Speaking countries.
   a. What are the first impression(s) that you draw from reading these two reports?

b. How do you comment on Report (A)?
c. How do you comment on Report (B)?

d. Given your understanding of the practices of forensic science, what do you think are the important factors to be considered when a university is deciding the faculty location for a forensic science course?
e. What levels of offer (non-award program, undergraduate, postgraduate, or undergraduate and postgraduate) would you expect an educational provider to run? Why do you say so?
f. From your perception, how might a forensic science program/ course be structured to reflect the daily practices of forensic science? What knowledge fields should comprise the subjects in the course structure?
g. What other curricular activities would you expect to see?

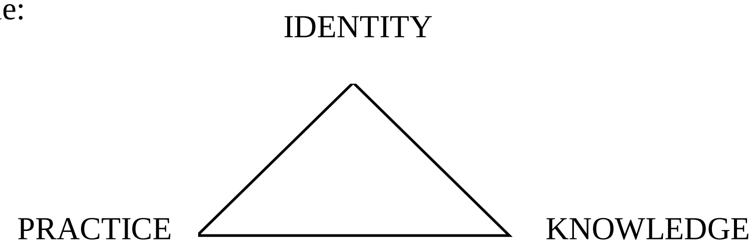
5) To finish up this interview, I would like to ask you few more questions. From your perception(s), what are the factor(s) that shape the identity of forensic science? Now I would like to list some factors in front of you, then I would like to ask you few questions about the influence (if any) of these factors in shaping the identity of forensic science. The factors are: <u>Forensic science practitioners</u>, <u>forensic science educators</u>, <u>politicians</u>, <u>society</u>, <u>judicial system</u>, <u>police</u>, <u>media</u>, and <u>technology</u>?

a. Which of these factors (if any) might influence the identity, image, and/or shape of forensic science?
b. Is this influence a major or a minor one? Why do you say so? (Repeat question after each selected factor).
c. Is there any other factor(s) that is not listed and may impact forensic science identity in one way or the other? If so what are these factors?

6) Some courses offered worldwide, are exclusively offered to members of police or military and the others are not. From your perception what are the

advantages and disadvantages of the involvement of civilians in forensic science?

7) Finally, couple of more questions. I would like you to consider the following triangle:



The first vertex represents the contributing knowledge bases in forensic science, from pure sciences, applied sciences, arts, and uniquely forensic pieces of knowledge. The second vertex represents the daily practice of forensic science: on crime scene, in the lab and in court. The third vertex represents the way in which forensic scientists, forensic science educators and associate professionals perceive the field, i.e. how they perceive the identity of forensic science.

a. How can you describe such a triangle, emphasising on the relationship between its three vertices.

b. Would you like to adjust anything in this triangle? If yes, what is the thing(s) that you would like to adjust? And why?

c. If you can imagine a picture, where you are standing in this picture along with other members of profession (judges, lawyers, policemen, etc), forensic practitioners (e.g. criminalistics, forensic biology lab technicians, fingerprint identification experts, etc) and forensic educators (e.g. lecturers and researchers). How can you describe the relationship that exists between all three categories in this picture?

d. Just simply, in your own words what is forensic science from your perception?

Appendix G

Plain Language Information Sheet

We would like to invite you to be a part of a study entitled:

Mapping the Complexity of Forensic Science: Implications for Forensic Science Education.

Many courses (e.g. forensic science and environmental science) developed substantially in the 20^{th} century in response to social, economic, legal and personal demands. This research will focus mainly on forensic science as a standing case study and as a critical and interesting analysis of an example of a new developing knowledge field.

Forensic science is the result of a complex combination of science (chemistry, biology, mathematics, physics), law (criminal law, civil law, judicial system regulations and litigations, administration of criminal justice, etc), and other forms of inquiry which are uniquely 'forensic' (e.g. fingerprinting, ear printing, tyre impressions examination, questioned document examination, etc).

This debate and controversy concerns three opinions among forensic science experts and related personnel on the education and training that a forensic science practitioner should acquire as a perquisite for his/her involvement in the field. The first opinion argues that 'forensic' courses should be open to science graduates especially chemistry/ biochemistry graduates, and that more related 'forensic' skills and competencies may be developed later through everyday practice and experience.

The second opinion argues that a forensic science undergraduate degree is essential for entry in the field as it provides the necessary forensic, legal and scientific backgrounds and basis for junior practitioners.

The third opinion suggests that tertiary education is not a necessity for some technical forensic science specialisations such as fingerprinting and tyre impressions examination, where expertise in those specialisations may be sufficiently acquired through experience and practice.

On the tertiary level of education, it is to be noted that there is no agreement on how a forensic science course/ program may look like: whether it should be offered within a particular department or as an inter-departmental course within the faculty; whether forensic science may start at an undergraduate level following high school or a graduate level following a science or a criminal justice degree.

Forensic science is still a young developing profession with high uncertainty of the knowledge bases that may comprise it and the daily practices that may reflect it. In other words, forensic science is a profession with a vague identity. Therefore, this research aims to explore some implications on forensic science education in terms of contributing knowledge that might form the basis of a pedagogical framework, under which a possible curriculum might be developed, reflecting both the nature of practice within the forensic science field and identity of forensic science.

The research comprises two components:

1. Document Analysis

The document analysis has already studied published curricula of 15 courses/programs offered by higher education institutes both in Australia and overseas. These courses/programs have been chosen following systematic selection criteria. Possible implications on nature of practice, knowledge base involved and nature of identity that have been revealed by these selected courses/programs, will be cross-compared with implications from the interviews for final analysis and examination.

2. Semi-structured interviews

Semi-Structured interviews will be conducted with three categories of interviewees:

- Forensic science educators,
- Practitioners
- Associated Personnel (Barristers, Criminologists, Policemen, etc)

The aim of the interviews is to study the perceptions held by the interviewees about forensic science practice, knowledge base and identity.

I am inviting you to be a participant in a semi-structured interview. The interview will be for approximately one hour and will take place at a location and time to be mutually agreed.

The interview will be tape-recorded and I will also take notes during the interviews. While the research presents little risk to participants, I will ensure that all data is de-identified prior to any publication. Your participation in the research will remain confidential to the researcher and his research supervisors. Your name will not be used in any reports which result from the research. It is your right to request access to the information you will provide during the interview and request to delete part or all of this information within a period of 6 months of completion of the interview. It is also your right to withdraw from this study at anytime.

We are very grateful that you have allowed us to explain the research project to you and would welcome your participation in this important investigation.

Yours sincerely,

Ahmad Samarji — **Student Researcher**

Tony Kruger — **Research Supervisor**

If you have further questions regarding this study they can be directed to Associate Professor Tony Kruger, School of Education, Victoria University (Tony.Kruger@vu.edu.au, Ph. 03 9919 7486) or the researcher Mr Ahmad Samarji (Ahmad.Samarji@research.vu.edu.au, Ph 03 9919 4458). If you have any queries or complaints about the way you have been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University of Technology, PO Box 14428 MCMC, Melbourne, 8001 Telephone no: **03-9919 4710.**

Appendix H

CONSENT FORM
CERTIFICATION BY PARTICIPANT

I, **……………………..…..,** of **……………………………………………** certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study entitled: **"Mapping the Complexity of Forensic Science: Implications for Forensic Science Education"** being conducted at Victoria University by Mr Ahmad Samarji (research student) and Associate Professor Tony Kruger (Principal Supervisor).

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me and that I freely consent to participating by being interviewed.

<u>Procedure</u>
Semi-Structured Interview

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed: **.. }**

Witness other than the researcher:………………………**}** **Date: ....**

If you have further questions regarding this study they can be directed to Associate Professor Tony Kruger, School of Education, Victoria University (Tony.Kruger@vu.edu.au, Ph. 03 9919 7486) or the researcher Mr Ahmad Samarji (Ahmad.Samarji@research.vu.edu.au, Ph 03 9919 4458. If you have any queries or complaints about the way you have been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University PO Box 14428 MCMC, Melbourne, 8001 Telephone no: **03-9919 4710.**

Appendix I

List of All Tables Included in the Document Analysis (Chapter 4)

Table-4a: List of 190 educational providers from various countries worldwide that offer forensic science courses/programs

Country	Education Provider
United States of America	University of Central Florida, University of West Florida, Florida International University, University of Florida, University of South Florida, St. Petersburg College, Florida Gulf Coast University, California State University (Sacramento), California State University (Fullerton), California State University (Chico), California State University (Stanislaus), California State University (Long Beach), University of California (Davis), University of California (Riverside),University of Alabama (Birmingham), University of Alabama (Tuscaloosa), Jacksonville State University, Northern Arizona University, Scottsdale Community College, Phoenix College, California State University(Los Angels), , City College of San Francisco, Rio Hondo College, San Jose State University, National University(San Diego), Grossmont College, Metropolitan State College of Denver, University of New Haven (West Haven), Dr. Henru C. Lee's Institute-University of New Haven, The University of Connecticut (Storrs), Tunxis Community College, Brevard Community College, Edison College, Barry University, Jacksonville State University, Clayton College & State University, Albany State University, Chaminade University, University of Illinois, Northwestern University, Southern Illinois University of Carbondale, Benedictine University, Iowa Western Community College, Kansas City Community College, Eastern Kentucky University, McNees State University, Loyola University(New Orleans), University of Baltimore, University of Maryland (Baltimore), Towson University, Prince George's College (Largo), Suffolk University, Bay Path College (Longmeadow), Williams College, MassBay Community College(Wellesley), Madonna University, Ferris State University (Big Rapids), Wayne State University, Michigan State University (MSU), Oakland Community College, Lake Superior State University, University of Southern Mississippi, University of Mississippi, Columbia College of Missouri, Southeast Missouri State University, Saint Louis University School of Medicine, University of Great Falls (Montana), Nebraska Wesleyan University, The College of New Jersey (Ewing), John Jay College of Criminal Justice(City Uni. of New York), Pace University(New York), St. John's University, Buffalo State College (Buffalo), State University of New York(Albany), Albany State University (Albany), State University of New York (Oswego), State University of New York(Canton), Rochester Institute of Technology (Rochester), Russell Sage College(Troy), Herkimer County Community College, University of North Carolina (Wilmington), Guilford College (Greensboro), Appalachian State University, Forsyth Technical Community College, University of North Dakota, Ohio University, Defiance College, The Ohio State University, Central Ohio Technical College, University of Cincinnati (Clermont), Jefferson Community College, Oklahoma State University(Tulsa), University of Central Oklahoma (UCO) (Edmond), Oklahoma State University (Oklahoma City), Western Oregon University, Southern Oregon University, Oregon State University, Arcadia University, Duquesne University (Pittsburgh), West Chester University, York College, Cedar Crest College, Mercyhurst College, Saint Francis University, Waynesburg College (Waynesburg), Keystone College, Lock Haven University, University of Rhode Island (URI) (Rhode Island), National Forensic Academy (University of Tennessee), Centre for Forensic Studies (Texas Tech University), University of North Texas Health Science Centre (Fort Worth), Sam Houston State University (Huntsville), Weber State University, University of Virginia, Virginia Commonwealth University (VCU) (Richmond), Northern Virginia Community College, Virginia Institute of Forensic Science and Medicine (VIFSM), New River Community College (Dublin), Seattle University (Seattle), Eastern Washington University, Tacoma Community College, The Law Enforcement Development Centre (LEDC), George Washington University (Washington DC), Eastern Washington University, Marshall University (Huntington), West Virginia University, Mountain State University (Beckley), University of Wisconsin-Milwaukee, University of Wisconsin (Platteville), Carroll College(Waukesha), University of California (Berkeley), Kansas State University (Manhattan),Villanova University (Villanova)

United Kingdom	Kings College London, University of Central Lancashire, Staffordshire University Stoke-on-Trent, University of Strathclyde Glascow Scottland, University of Kent, South Bank University, University of Glamorgan, National Training Center (NTC), University of Northumbria, University of Glasgow, University of Bradford, University of Durham, Loughborough University, University of Dundee, University of Teesside, University of Glamorgan Wales, Liverpool John Moores University, Anglia Polytechnic University Cambridge.
Australia	University of Technology, Sydney (UTS), Murdoch University, Griffith University, RMIT University, Deakin University, Geelong, University of Western Australia, Canberra Institute of Technology , Queensland University of Technology (QUT), Swinburne University, The Flinders University of South Australia , University of Canberra , Central Queensland University, La Trobe University, University of Ballarat, Victoria University of Technology, Curtin University of Technology, University of NewCastle, University of Western Sydney
Germany	Humboldt University of Berlin
Turkey	Institute of Legal & Forensic Sciences, Istanbul, Turkey
New Zealand	The University of Auckland
Canada	British Columbia Institute of Technology, University of Windsor, University of Toronto at Mississauga, Mount Royal College Calgary, Justice Institute of BC Forensic Science Technology, Laurentian University, Trent University
Switzerland	Institute of Police Science and Criminology of University of Lausanne
India	Dr. Harisingh Gour University Sagar MP, Punjabi University Patiala, University of Madras Chennai , University of Mysore Karnataka, Osmania Universty Hyderabad, Rai University, National Law University, Jodhpur
Poland	University of Crakow
Italy	University of Italy

Table-4b: Exclusion-based criterion implemented on 190 courses/programs						
Course/Program Code	Exc-a	Exc-b	Exc-c	Exc-d	Exc-e	Result
FOR-650	1	1	1	0	_	Excluded
FOR-651	1	1	0	_	_	Excluded
FOR-652	1	1	0	_	_	Excluded
FOR-653	1	1	1	1	0	Excluded
FOR-654	1	1	1	1	1	Passed
FOR-655	1	1	1	1	0	Excluded
FOR-656	1	1	1	1	0	Excluded
FOR-657	1	1	0	_	_	Excluded
FOR-658	1	1	1	0	_	Excluded
FOR-659	1	1	0	_	_	Excluded
FOR-660	1	1	1	1	1	Passed
FOR-450	1	1	1	0	_	Excluded
FOR-451	1	1	1	1	1	Passed
FOR-452	1	1	1	0	_	Excluded
FOR-453	1	1	1	1	1	Passed
FOR-454	1	1	1	0	_	Excluded
FOR-455	1	1	1	0	_	Excluded
FOR-456	1	1	1	1	1	Passed
FOR-457	1	1	1	0	_	Excluded
FOR-458	1	1	1	1	1	Passed
FOR-459	1	1	1	1	1	Passed
FOR-460	1	1	1	0	_	Excluded
FOR-461	1	1	1	0	_	Excluded
FOR-462	1	1	0	_	_	Excluded
FOR-463	1	1	1	0	_	Excluded
FOR-464	1	1	0	_	_	Excluded
FOR-465	1	1	1	1	1	Passed
FOR-466	1	1	0	_	_	Excluded
FOR-467	1	0	_	_	_	Excluded
FOR-468	1	1	1	1	1	Passed
FOR-300	1	1	1	1	0	Excluded
FOR-301	1	1	1	1	1	Passed
FOR-302	1	1	1	1	1	Passed

FOR-303	1	1	1	1	0	Excluded
FOR-304	1	1	0	_	_	Excluded
FOR-305	1	0	_	_	_	Excluded
FOR-306	1	1	1	1	1	Passed
FOR-307	1	1	1	1	1	Passed
FOR-308	1	1	1	1	1	Passed
FOR-309	1	1	1	1	1	Passed
FOR-310	1	1	1	0	_	Excluded
FOR-311	1	0	_	_	_	Excluded
FOR-312	1	1	1	0	_	Excluded
FOR-313	1	1	1	1	0	Excluded
FOR-314	1	1	1	0	_	Excluded
FOR-315	1	1	1	0	_	Excluded
FOR-316	1	1	1	1	1	Passed
FOR-317	1	0	_	_	_	Excluded
FOR-318	1	1	0	_	_	Excluded
FOR-319	1	1	1	0	_	Excluded
FOR-320	1	1	1	0	_	Excluded
FOR-321	1	1	1	1	0	Excluded
FOR-322	1	1	1	1	0	Excluded
FOR-323	1	1	0	_	_	Excluded
FOR-324	1	0	_	_	_	Excluded
FOR-325	1	1	1	1	1	Passed
FOR-326	1	1	1	1	1	Passed
FOR-327	1	1	1	1	1	Passed
FOR-328	1	1	1	1	1	Passed
FOR-329	1	1	0	_	_	Excluded
FOR-330	1	1	1	1	1	Passed
FOR-331	1	1	1	0	_	Excluded
FOR-250	1	1	1	1	1	Passed
FOR-251	1	1	1	1	1	Passed
FOR-252	1	1	1	1	1	Passed
FOR-253	1	1	1	0	_	Excluded
FOR-254	1	1	1	0	_	Excluded
FOR-255	1	1	1	1	1	Passed

FOR-256	1	1	1	1	1	Passed
FOR-257	1	1	1	1	1	Passed
FOR-258	1	1	1	0	_	Excluded
FOR-259	1	1	0	_	_	Excluded
FOR-260	1	1	1	1	0	Excluded
FOR-261	1	1	1	0	_	Excluded
FOR-262	1	1	1	1	0	Excluded
FOR-263	1	1	1	1	0	Excluded
FOR-264	1	1	1	1	1	Passed
FOR-265	1	1	1	1	0	Excluded
FOR-266	1	1	1	1	1	Passed
FOR-267	1	1	0	_	_	Excluded
FOR-268	1	1	1	0	_	Excluded
FOR-269	1	0	_	_	_	Excluded
FOR-270	1	1	1	0	_	Excluded
FOR-271	1	1	1	0	_	Excluded
FOR-272	1	1	1	0	_	Excluded
FOR-273	1	1	1	1	1	Passed
FOR-274	1	1	1	0	_	Excluded
FOR-275	1	0	_	_	_	Excluded
FOR-276	1	1	1	1	1	Passed
FOR-277	1	1	1	1	1	Passed
FOR-350	1	1	1	1	0	Excluded
FOR-351	1	1	1	1	1	Passed
FOR-352	1	1	1	1	1	Passed
FOR-353	1	1	1	1	1	Passed
FOR-354	1	1	1	1	1	Passed
FOR-355	1	1	1	1	0	Excluded
FOR-356	1	1	1	1	1	Passed
FOR-357	1	1	1	0	_	Excluded
FOR-358	1	1	1	1	1	Passed
FOR-359	1	1	1	1	0	Excluded
FOR-360	1	1	1	1	1	Passed
FOR-361	1	1	1	0	_	Excluded
FOR-362	1	1	1	1	1	Passed

FOR-363	1	1	1	1	1	Passed
FOR-364	1	1	1	1	1	Passed
FOR-365	1	1	1	1	1	Passed
FOR-366	1	1	1	1	0	Excluded
FOR-367	1	1	1	1	0	Excluded
FOR-368	1	1	1	0	_	Excluded
FOR-369	1	1	1	1	0	Excluded
FOR-370	1	1	1	1	1	Passed
FOR-371	1	1	1	1	1	Passed
FOR-372	1	1	1	1	0	Excluded
FOR-373	1	1	0	_	_	Excluded
FOR-374	1	1	1	1	1	Passed
FOR-375	1	1	1	1	1	Passed
FOR-376	1	1	1	0	_	Excluded
FOR-377	1	1	1	1	1	Passed
FOR-550	1	1	1	1	1	Passed
FOR-551	1	1	1	1	1	Passed
FOR-552	1	1	1	1	0	Excluded
FOR-553	1	0	_	_	_	Excluded
FOR-554	1	1	1	1	1	Passed
FOR-555	1	1	1	0	_	Excluded
FOR-556	1	1	1	1	1	Passed
FOR-557	1	1	0	_	_	Excluded
FOR-558	1	1	1	1	1	Passed
FOR-559	1	1	1	1	1	Passed
FOR-560	1	1	1	1	1	Passed
FOR-561	1	1	1	1	1	Passed
FOR-700	1	1	0	_	_	Excluded
FOR-701	1	0	-	_	_	Excluded
FOR-702	1	0	-	_	_	Excluded
FOR-703	0	_	-	_	_	Excluded
FOR-704	0	_	-	_	_	Excluded
FOR-705	1	1	1	1	1	Passed
FOR-706	1	1	1	1	1	Passed
FOR-707	1	1	1	0	_	Excluded

FOR-708	1	1	1	0	_	Excluded
FOR-709	1	1	1	1	1	Passed
FOR-710	1	1	1	0	_	Excluded
FOR-711	1	1	1	0	_	Excluded
FOR-712	1	1	1	0	_	Excluded
FOR-713	1	1	1	0	_	Excluded
FOR-714	1	1	0	-	_	Excluded
FOR-715	1	1	1	1	1	Passed
FOR-716	1	0	_	_	_	Excluded
FOR-750	1	1	1	0	_	Excluded
FOR-751	1	1	0	_	_	Excluded
FOR-752	1	1	1	0	_	Excluded
FOR-753	1	1	1	0	_	Excluded
FOR-754	1	1	1	1	1	Passed
FOR-755	1	1	1	1	1	Passed
FOR-756	0	_	_	_	_	Excluded
FOR-757	1	1	1	1	1	Passed
FOR-758	1	1	1	1	1	Passed
FOR-759	1	1	1	1	1	Passed
FOR-760	1	0	_	_	_	Excluded
FOR-761	1	1	1	0	_	Excluded
FOR-762	1	1	1	1	1	Passed
FOR-763	1	1	1	1	1	Passed
FOR-764	1	1	1	1	0	Excluded
FOR-765	1	1	1	1	1	Passed
FOR-766	1	1	1	1	1	Passed
FOR-767	1	1	1	1	1	Passed
FOR-768	1	1	0	_	_	Excluded
FOR-769	1	1	1	1	1	Passed
FOR-770	1	1	0	_	_	Excluded
FOR-771	1	1	1	1	1	Passed
FOR-772	1	1	1	1	0	Excluded
FOR-773	1	1	1	1	1	Passed
FOR-774	1	1	1	1	1	Passed
FOR-775	1	1	1	1	1	Passed

FOR-776	0	–	–	–	–	Excluded
FOR-777	0	–	–	–	–	Excluded
FOR-778	0	–	–	–	–	Excluded
FOR-779	0	–	–	–	–	Excluded
FOR-780	0	–	–	–	–	Excluded
FOR-781	0	–	–	–	–	Excluded
FOR-800	0	–	–	–	–	Excluded
FOR-801	0	–	–	–	–	Excluded
FOR-802	0	–	–	–	–	Excluded
FOR-803	0	–	–	–	–	Excluded
FOR-804	1	1	1	1	1	Passed
FOR-805	1	1	1	1	1	Passed
FOR-806	1	1	1	1	0	Excluded
FOR-807	1	1	0	–	–	Excluded
FOR-850	1	0	–	–	–	Excluded
FOR-851	1	1	1	1	1	Passed
FOR-852	1	1	1	0	–	Excluded

Table- 4c: The Outcome of the Implementation of the Exclusion-Based Criterion	
Excluded Programs	Passed Programs
112 programs offered worldwide were excluded for the following reasons: • 49 programs fell under exclusion factor: a, b, or c. • 63 programs fell under exclusion factor: d or e.	78 programs offered by various educational providers passed the exclusion process as these courses: • were offered in English speaking countries, • possessed valid website addresses, • fell within the research’s definition of forensic science, • provided detailed content description, • emphasised their aims/objectives and potential career opportunities.

Table-4d: List of the 78 programs nominated for the second stage of the selection criteria: Representative-Classification Criterion					
FOR-654	FOR-308	FOR-257	FOR-362	FOR-558	FOR-762
FOR-660	FOR-309	FOR-264	FOR-363	FOR-559	FOR-763
FOR-451	FOR-316	FOR-266	FOR-364	FOR-560	FOR-765
FOR-453	FOR-325	FOR-273	FOR-365	FOR-561	FOR-766
FOR-456	FOR-326	FOR-276	FOR-370	FOR-705	FOR-767
FOR-458	FOR-327	FOR-277	FOR-371	FOR-706	FOR-769
FOR-459	FOR-328	FOR-351	FOR-374	FOR-709	FOR-771
FOR-465	FOR-330	FOR-352	FOR-375	FOR-715	FOR-773
FOR-468	FOR-250	FOR-353	FOR-377	FOR-754	FOR-774
FOR-301	FOR-251	FOR-354	FOR-550	FOR-755	FOR-775
FOR-302	FOR-252	FOR-356	FOR-551	FOR-757	FOR-804
FOR-306	FOR-255	FOR-358	FOR-554	FOR-758	FOR-805
FOR-307	FOR-256	FOR-360	FOR-556	FOR-759	FOR-851

Table-4e: Classification and Categorisation of the 78 Passed Programs

Course Code	Categorizing Group	Administering Department
FOR-654	I	Administration of Justice Program
FOR-660	II	Department of Sociology and Criminal Justice
FOR-451	IV	Contribution of Faculty (multi-dept)
FOR-453	I	Administration of Justice
FOR-456	IV	Department of Professional Studies
FOR-458	II	Department of Chemistry
FOR-459	V	School of Public Safety and Professional Studies
FOR-465	V	International Forensic Research Institute
FOR-468	I	Public Safety Institute
FOR-301	I	Unspecified
FOR-302	I	Professional and Technical studies
FOR-306	III	Department of Criminal Justice
FOR-307	III	Natural Sciences and Mathematics
FOR-308	IV	College of Pharmacy
FOR-309	I	School of Continuing Studies
FOR-316	II	Department of Chemistry
FOR-325	III	College of Science and Mathematics
FOR-326	II	School of criminal justice
FOR-327	IV	Multidisciplinary: science, chemistry, Criminal justice
FOR-328	IV	School of criminal Justice
FOR-330	III	Department of Chemistry and Environmental Science
FOR-250	III	Department of Chemistry and Biochemistry
FOR-251	III	Criminal Justice Administration
FOR-252	IV	College of Science and Mathematics
FOR-255	IV	Forensic Program within University
FOR-256	II	Department of Chemistry
FOR-257	V	Department of Sciences
FOR-264	III	Public Safety: Criminal Investigation
FOR-266	III	Department of Chemistry and Physics
FOR-273	III	Department of Chemistry and Biochemistry
FOR-276	I	Division of Allied Health and Public Service
FOR-277	I	Humanities & Social Sciences Division
FOR-351	IV	Centre for Health Sciences

FOR-352	V	Department of Chemistry
FOR-353	I	Public Safety
FOR-354	II	Department of Chemistry
FOR-356	II	Department of chemistry
FOR-358	I	Wecht Institute of Forensic Science
FOR-360	III	Physical Science Department
FOR-362	III	Applied Forensic Sciences
FOR-363	II	Department of Chemistry, Mathematics, and Physics
FOR-364	III	Department of Biology, Chemistry, & Geology: Multidisciplinary
FOR-365	II	Biological Science
FOR-370	IV	Graduate School of Biomedical Sciences
FOR-371	V	Department of chemistry
FOR-374	V	Department of Forensic Science
FOR-375	I	Administration of Justice
FOR-377	I	Administration of Justice Department
FOR-550	III	Criminal Justice Department
FOR-551	II	Department of Chemistry and Biochemistry
FOR-554	IV	Department of Forensic Sciences
FOR-556	IV	Forensic Science Centre
FOR-558	III	School of Arts and Sciences
FOR-559	I	Centre for Forensic Science
FOR-560	II	Department of Chemistry & Engineering Physics
FOR-561	II	Department of Chemistry and Biochemistry
FOR-705	IV	School of Biomedical and Health Sciences
FOR-706	V	Department of Forensic and Investigative Science
FOR-709	III	Multidisciplinary
FOR-715	III	Department of Chemical and Forensic Science
FOR-754	III	School of Biomolecular Science
FOR-755	V	Department of Forensic Science and Chemistry
FOR-757	V	Department of chemistry/ Department of Cell and Molecular Biology
FOR-758	III	School of Biological Science and Biotechnology
FOR-759	V	School of Biomolecular and Biomedical Science
FOR-762	IV	Centre for Forensic Science
FOR-763	V	Department of Laboratory and Forensic Science

FOR-765	I	Industrial Science Department
FOR-766	III	Faculty of Science and Engineering
FOR-767	III	Division of Health, Design and Sign
FOR-769	IV	Faculty of Science Technology, and Engineering
FOR-771	II	School of Molecular Science
FOR-773	III	Faculty of Science and Information of Technology
FOR-774	III	School of Science, Food, Horticulture
FOR-775	IV	Department of Chemistry
FOR-804	III	Forensic Science Technology Program
FOR-805	III	Inter-Faculty Program
FOR-851	III	Department of Forensic Science

Table 4f: Distribution of the Final 15 Selected Courses over the Categorising Groups						
RESULTS	GROUP (I)	GROUP (II)	GROUP (III)	GROUP (IV)	GROUP (V)	Total
Distribution of courses/ programs over the 5 Groups	14/78	13/78	25/78	15/78	11/78	78
Weighed Representative Percentage (WRP)	18%	16.50%	32.00%	19.00%	14.5%	100%
Number of courses/ programs representing each Group	3	2	5	3	2	15

Table-4g: Implementation of the Point-Based Criterion										
Course Code	Group	PB_1 [55]	PB_2 [56]	PB_3 [57]	PB_4 [58]	PB_5 [59]	PB_6 [60]	PB_7 [61]	PB_8 [62]	**Total**
FOR-654	I	0	0	0	0.5	1	0	0	2.5	4
FOR-660	II	0	0	1	1	0	0	1	2.5	5.5
FOR-451	IV	0	1	1	1	0	0	1	3	7
FOR-453	I	0	0	0	0	0	0	1	2.5	3.5
FOR-456	IV	0	1	0	0	0	0	1	2.5	4.5
FOR-458	II	0	0	0	1	0	1	0	3	5
FOR-459	V	0	1	1	1	1	0	1	2.5	7.5
FOR-465	V	0	1	1	1	0	0	1	2.5	6.5
FOR-468	I	0	1	0	0	0	0	0	2.5	3.5
FOR-301	I	0	1	0	0	0	0	0	2.5	3.5
FOR-302	I	0	0	0	1	0	0	0	2.5	3.5
FOR-306	III	0	1	1	0.5	0	0	0	3	5.5

[55] PB_1 is (1pt) for Australian provider

[56] PB_2 is (1pt) for course prerequisite(s)

[57] PB_3 is (1pt) for curriculum disciplinary implications

[58] PB_4 is (1pt) for relationship to external authorities

[59] PB_5 is (1pt) for indication of teaching methods

[60] PB_6 is (1pt) for assessment practices

[61] PB_7 is (1pt) for practitioner participation in course delivery

[62] PB_8 is (3pts) for overall rating of course: subjects' description, course aims/objectives, and potential career opportunities.

FOR-307	III	0	0	0	1	1	0	0	2.5	4.5
FOR-308	IV	0	1	0.5	1	0.5	0	1	3	7
FOR-309	I	0	0	0	0	0	0	0	3	3
FOR-316	II	0	0	0	1	0	0	0	2	3
FOR-325	III	0	0	0	1	0	0	1	1.5	3.5
FOR-326	II	0	0	0	1	0	0	0	2	3
FOR-327	IV	0	1	0	1	0	0	1	2.5	5.5
FOR-328	IV	0	1	1	1	0.5	0	1	3	7.5
FOR-330	III	0	0	0	0.5	0	0	0	2	2.5
FOR-250	III	0	0	1	0	0	0	0	2	3
FOR-251	III	0	0	1	0	0	1	0	3	5
FOR-252	IV	0	1	0	1	0	0	1	1.5	4.5
FOR-255	IV	0	1	1	0	1	0	1	3	7
FOR-256	II	0	0	1	1	0	0	0	3	5
FOR-257	V	0	1	0.5	1	0.5	1	0	3	7
FOR-264	III	0	1	0	1	0	0	0	3	5
FOR-266	III	0	1	1	0	0	0	0	1.5	3.5
FOR-273	III	0	1	1	1	0	0	1	2.5	6.5
FOR-276	**I**	**0**	**1**	**0**	**0.5**	**1**	**0**	**0**	**3**	**5.5**
FOR-277	I	0	1	0	0.5	0	0	0.5	2.5	4.5
FOR-351	IV	0	1	0	0	0	0	0	3	4
FOR-352	V	0	1	0	0	0	0	1	3	5
FOR-353	I	0	0	0	0	0	0	0.5	2.5	3
FOR-354	II	0	0	0	0	0	0	1	2.5	3.5
FOR-356	II	0	0	1	0	0	0	0	3	4
FOR-358	**I**	**0**	**0**	**1**	**0**	**0.5**	**0**	**0**	**3**	**4.5**
FOR-360	III	0	1	0	1	1	0	1	3	7
FOR-362	III	0	0	1	0	0.5	0.5	0	3	5
FOR-363	II	0	0	0	0	0	0	0	2.5	2.5
FOR-364	III	0	1	1	1	0	0	0	3	6
FOR-365	II	0	0	1	0	0	0	0	3	4
FOR-370	IV	0	0	0	1	0	1	0	3	5
FOR-371	V	0	1	1	0	0	0	1	3	6
FOR-374	V	0	1	0	1	0.5	0	1	3	6.5
FOR-375	**I**	**0**	**0.5**	**0**	**0**	**1**	**0**	**0**	**3**	**4.5**

FOR-377	I	0	0	0	0	0.5	0	0	2.5	3
FOR-550	III	0	0	1	1	1	0	1	3	7
FOR-551	**II**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**3**	**6**
FOR-554	**IV**	**0**	**1**	**1**	**1**	**0.5**	**0**	**1**	**3**	**7.5**
FOR-556	**IV**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**3**	**8**
FOR-558	**III**	**0**	**1**	**0**	**1**	**1**	**0**	**1**	**3**	**7**
FOR-559	I	0	0	0.5	1	0	0	1	2	4.5
FOR-560	**II**	**0**	**1**	**1**	**1**	**1**	**0**	**1**	**2.5**	**7.5**
FOR-561	II	0	0	1	1	1	0	0	2.5	5.5
FOR-705	IV	0	1	0	0	0	1	1	3	6
FOR-706	**V**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**3**	**8**
FOR-709	**III**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**9**
FOR-715	**III**	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**3**	**8**
FOR-754	**III**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**3**	**7**
FOR-755	V	0	0	0	0	0	0	0	3	3
FOR-757	**V**	**1**	**1**	**1**	**1**	**1**	**0.5**	**1**	**3**	**9.5**
FOR-758	III	1	0	0	1	0	0	0	3	5
FOR-759	V	1	1	1	1	0	0	0	2.5	6.5
FOR-762	**IV**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**2**	**8**
FOR-763	V	1	1	1	1	1	0	1	2	8
FOR-765	I	1	1	0	0	0	0	0	2.5	4.5
FOR-766	**III**	**1**	**1**	**0**	**1**	**1**	**0**	**1**	**3**	**8**
FOR-767	III	1	0.5	0	0	0	0	0	3	4.5
FOR-769	IV	1	1	0	0	0	0	0	2.5	4.5
FOR-771	II	1	1	0	1	0	0	0	2.5	5.5
FOR-773	III	1	1	0	0	1	0	0	3	6
FOR-774	III	1	1	0	0	0	0	0	3	5
FOR-775	IV	0	1	0	1	0	1	1	2.5	6.5
FOR-804	III	0	1	1	0	0.5	0	0.5	3	6
FOR-805	III	0	1	1	1	0	0	1	2	6
FOR-851	III	0	1	0	1	0.5	0.5	1	3	7

Table-4h: List of the final set of 15 programs considered by the document analysis	
Group I (3 courses)	FOR-276, FOR-375 & FOR-358
Group II (2 courses)	FOR-560 & FOR-551
Group III (5 courses)	FOR-715, FOR-558, FOR-766, FOR-709 & FOR-754
Group IV (3 courses)	FOR-762, FOR-554 & FOR-556
Group V (2 courses)	FOR-706 &FOR-757

Table-4i: Distribution of Forensic Science Programs across Administering Departments	
Chemistry Departments	23%
Stand-alone Forensic Science Departments	17%
Other (Science)* Departments	15%
Departments of Criminal Justice	13%
Other• Departments	11%
Biology Departments	10%
Multi-Departmental Programs	6%
Public Safety Departments	5%

Table-4j: Distribution of Forensic Science Programs across Academic Levels of Offer	
Group I: Non- Award Degrees	18.00%
Group II: Minor Degrees	16.50%
Group III: Undergraduate Degrees	32.00%
Group IV: Postgraduate Degrees	19%
Group V: Complete Programs (Undergraduate &Postgraduate Degrees).	14.50%

* Other (science) Departments incorporated schools of science, physical science departments, etc. i.e. this category comprised departments with a general science umbrella without emphasis on a dominating science discipline; This is why it was termed as other (science) departments

• Other Departments incorporated departments/divisions such as centre for health sciences, humanities & social sciences division, department of professional studies, etc.

Appendix J

Group I/ Course Code: FOR-276

KNOWLEDGE

a. Curriculum nature and organisation

Course is mainly offered to individuals with basic and general educational background (year 12 students or law enforcement personnel with basic or general knowledge). Course follows an interdisciplinary approach.

b. Knowledge fields in course

Course structure incorporates: 13 F (forensic subjects), 2 C (chemistry subjects), 3 L (legal studies subjects), 2 B (biology subjects), 1 M (mathematic subject), 1 P (physics subject) , and 6 general education subjects.

c. Emphasised competencies & skills

Stressing competencies and skills for long life learning, critical thinking, and problem solving.

d. Connections between knowledge fields and curriculum components

There is a heavy component of various forensic subjects which relates to the course objective of graduating criminalistics capable of working in field, at lab and at court.

PRACTICE

a. Place of forensic practice in course

Practice is reflected in curriculum applications on crime scene: photography, criminalistics, and questioned document examination.

b. Extent of practice

Forensic science subjects involved are set to improve and develop specific forensic specialities in relation to crime scene investigation, photography, and questioned document examination. Hence the course is mainly objected towards already existing law enforcement personnel that either wish to change over to the forensic area or are already involved in the forensic area and wish to develop, advance, and backup their practice with education; hence seeking promotion.

c. Pedagogical practice

Course aims to graduate forensic scientists that are capable of identifying, collecting, and preserving physical evidence at field; interpret the evidence in lab; present evidence analysis at court when serving as expert witness.

d. Practitioners' Participation in Course Delivery

Practitioners contribute in a major way in course delivery especially with the uniquely forensic science subjects: crime scene investigation, photography, document examination, etc.

IDENTITY

a. Course Type

Non- award program (Group I)

b. Course location

Division of Allied Health & Public Service

c. Relation to other courses

Related to science courses

d. Evidence of course outcomes

Careers in traditional law enforcement positions, field technicians (CSI), and crime laboratory areas: chemistry, biology, or toxicology.

e. Relationship to external authorities

Indication that the course is mainly offered to already existing law enforcement personnel.

f. Other attribute(s) to identity:

- Course caters for both already employed law enforcement personnel wishing to develop and improve their forensic science skills and civilians interested in forensic science.
- Course emphasises that criminalistics is the 54th fastest growing job in the U.S.A.

COMMENTS: This is a non- award (group I) forensic science technology course. Its curriculum emphasises a general and basic science course centred on forensic applications on crime scene: photography, criminalistics, questioned document. This course is mainly organised for already existing law enforcing personnel who would like to improve their skills within the field or promote to a crime scene technician position and to individuals interested in applying to a position as a crime scene officer or law enforcement officer. The course is mostly an evening part-time course.

Group I/ Course Code: FOR-375

KNOWLEDGE

a. Curriculum nature and organisation

Program offers 2 non-award courses: a general forensic investigation course and advanced forensic investigation course. The general course aims to train individuals that have been already involved in the field for development and promotion. This course is also suitable for individuals interested in exploring the field (general knowledge or education). The advanced course aims to provide continuing training for private investigators, law enforcement officers, persons licensed in various security and/or investigative related areas. The program follows an interdisciplinary approach in course delivery.

b. Knowledge fields in course

Course Structure: 6 F, 4 0, 2 L, 1 M (science courses: chemistry & Biology are electives and selected according to desired forensic speciality or emphasis).

c. Connections between knowledge fields and curriculum components

Curriculum components meet the aims and objectives of providing continuing training for law enforcement personnel through providing an administration of justice-based course with a small general science component (chemistry, biology and maths) and a heavy forensic criminalistics subjects.

PRACTICE

a. Place of forensic practice in course

within university only

b. Extent of practice:

within university through lecture and laboratory in a proportion of approximately 1:1

c. **Practitioners' Participation in Course Delivery**

Practitioners contribute in course delivery through the teaching of uniquely forensic subjects.

IDENTITY

a. Course Type

Non- award program (Group I)

b. Course Location

Administering Department: Administration of Justice

c. Relation to other courses

Curriculum can be applied towards electives in the applied degree in administration of justice.

d. Evidence of course outcomes

Mainly oriented to personnel already employed in law enforcement agencies.

e. other identity attributes:

There is a need to offer academic courses to members of police and forensic science services as part of their continuing educational program. This is because some of the forensic practitioners were employed well before all the advances in science and technology have emerged and found their way into practical implementation (e.g. DNA profiling, automated fingerprint identification systems, etc). Such experienced practitioners may struggle with these new techniques. Hence, they may need to backup their practice with some sort of formal education which stresses such advances.

Comments:

This is a non-award program (group I) which is directed towards personnel that have been already involved in the forensic field and/or forensic related areas (private investigators, law enforcement officers, security officers, etc) for various purposes: training, improvement and/or promotion. The course, as evident from subject description, is an administration of justice-based course with a small general science component and a heavy forensic criminalistics component.

Group I/ Course Code: FOR-358

KNOWLEDGE

a. Curriculum nature and organisation

Certificate in forensic science and law; curriculum follows a unique multidisciplinary approach.

b. Knowledge fields in course

3F & 2L

c. Connections between knowledge fields and curriculum components

This program claims to investigate the promise and the possibilities modern science brings to the pursuit of the truth in civil, criminal, and family proceedings. This aim exceeds the knowledge and competencies that maybe revealed by a 5 subject course: 3F and 2L. Aims/Objectives seem to be over-exaggerated.

PRACTICE

a. Place of forensic practice in course

Practical component is reflected in lab work undertaken within the course.

b. Extent of practice

18 % of entire class hours

c. Practitioners' participation in course delivery

Program brings together professionals from a variety of disciplines to teach the various subjects in its curriculum

IDENTITY

a. Course Type

Non- award program (Group I)

b. Course Location

Stand-alone institute of forensic science.

c. Relation to other courses

Stand- alone course not connected with other courses.

d. Evidence of course outcomes

Directed to people who are already employed in a forensic, law enforcement, and/or a forensic-related field in order to improve their competencies and knowledge base.

e. other identity attributes:

Program emphasises that as seen on TV shows forensic science investigates the promise and the possibilities modern science brings to our pursuit of the truth.

Comments:

This is a non-award program (group I) that mainly aims to give a broad understanding of forensic science and law. It is more directed towards individuals who are already employed in a forensic, law enforcement, and/or a forensic-related career as is evident from the curriculum organisation and delivery (Lectures takes place only on Saturdays as not to interfere with the working hours of law enforcement officers and forensic practitioners undertaking this course). This course has both theoretical and practical components with lab work forming around 18% of the entire class hours.

Group II/ Course Code: FOR-560

KNOWLEDGE

a. Curriculum nature and organisation

Program is multidisciplinary in nature; It offers two courses: a major degree in chemistry and associated minor degrees in either chemistry criminalistics or biology criminalistics (DNA). A major prerequisite is high school with maximum number of physics, mathematics, chemistry, biology and English subjects.

b. Knowledge fields in course

- Criminalistics Emphasis (Chemistry): 2F, 21 C, 3 L, 4M, 1B, 4P, 11O (including public speaking)
- Criminalistics Emphasis (DNA): 2 F, 15 C (includes some biochemistry courses), 3L, 3M, 4B, 4P, 11 O (including public speaking).

Forensic science is not directly approached through uniquely forensic courses but through: chemistry subjects (e.g. analytical, physical, organic chemistry), criminal justice subjects (e.g. criminal investigation, criminalistics procedure and evidence) collecting, analysing and reporting evidence to court), biology subjects (e.g. molecular biology: DNA), maths subjects (e.g. statistics), and physics subjects.

c. Connections between knowledge fields and curriculum component

One of the objectives of this program is to graduate criminalistics with strong science (particularly chemistry) background. This is evident from the high number of chemistry and science subjects incorporated and the content of these subjects.

PRACTICE

a. Place of forensic practice in course:

Both in lab and through lectures, seminars and through visits to law enforcement agencies and relevant industries.

b. Extent of practice:

The program includes interdisciplinary training in the examination and analysis of physical evidence and substantial coursework in criminal justice and biochemistry. This provides graduates with valuable cross-disciplinary experiences related to the field including expert witness testimony.

c. Pedagogical practice:

Program offers interdisciplinary training with valuable cross-disciplinary experiences related to the field.

d. Practitioners' participation in course delivery:

Program participates in the "Alchemists", an active student affiliate of the American Chemical Society. Alchemists' activities include field trips, chemical demonstrations at area elementary schools, and presentations by/ informal discussions with visiting industrial and academic chemists. This program also participates in the Criminal Justice Association. Activities include speakers, field trips, and social events. Field trips include visits to crime labs, prisons, and drug rehabilitation centres.

IDENTITY

a. Course Type:

Minor/ associate degree (Group II)

b. Course Location:

Housed in the department of chemistry & engineering physics.

c. Relation to other courses:

Program is placed in chemistry but offered in conjunction with the criminal justice department.

d. Evidence of course outcomes:

Variety of alternative careers which require a chemistry degree with a significant biological chemistry experience; subsequent graduate study in forensic science.

e. Relationship to external authorities:

Program accredited by the American Chemistry Society.

f. Other identity attributes:

Chemistry has been mainly dominating forensic science up until 1990s when DNA technology revolution started.

Comments: This is an associate program (Group II) which prepares students for careers and subsequent graduate study in forensic science. This program offers a chemistry degree with a significant biological chemistry experience needed for a variety of alternative careers. Program emphasises that a criminalist with a degree based in chemistry represents one of the most sought-after backgrounds in criminalistics. This program provides a comprehensive understanding of chemistry, by doing so it offers graduates more job opportunities. It criticises some other programs which graduate students without a comprehensive understanding in one of the main science streams (chemistry or biology).

Group II/ Course Code: FOR-551

KNOWLEDGE

a. Curriculum nature and organisation

Program is multidisciplinary in nature; it offers a major degree in chemistry and an associated minor one in forensics. This degree is a chemistry one with an emphasis in forensics and a large compliment of biology for DNA work. Mathematics and science are prerequisites for entry into the program.

b. Knowledge fields in course

-Due to the increased use of automated instrumentation and DNA technology, a solid grounding in analytical chemistry, organic chemistry, biochemistry, genetics, and molecular biology are recommended.

-Course Structure: F 5, C 15, B 7, M 3, L 1, P 3, O 1 (public speaking)

c. Connections between knowledge fields and curriculum components

This major is specifically designed to meet entry-level work in state, local, and federal forensic science laboratories. It also offers the flexibility of a chemistry degree, which will open up additional opportunities for further studies and for other career options. The objective of the program seems to be met through the presence:

- Forensic, chemistry, and biology subjects and public speaking subjects, in addition to lab training and internship with regional forensic labs which give a practical dimension to the program.
- Heavy chemistry component (15 courses) and certification by American Chemical Association which offer the flexibility and opportunities of a chemistry degree.

PRACTICE

a. Place of forensic practice in course:

Both lab-work within university and in collaboration with working crime-laboratory and through internship.

b. Extent of practice:

- Collaboration, research and integration with a working crime laboratory
- Competitive internships at regional forensic labs which are integrated into the curriculum along with research and independent study.
- Emphasis on Automated instrumentation and DNA technologies

c. Pedagogical practice:

Due to the increased use of automated instrumentation and DNA technology, a curricular approach which emphasises solid grounding in analytical chemistry, organic chemistry, biochemistry, genetics, and molecular biology is adopted.

d. Practitioners' participation in course delivery:

Forensic classes are taught by practitioners in the forensic science field (state patrol).

e. Other attribute(s) to practice:

- There is no consensus on how agencies or jurisdictions handle crime scene processing and analysis. Sometimes police officers process crime scene themselves and forensic specialists are called when needed. However, the more the technical demands of evidence collection and documentation increase, the more the requirement for higher education qualifications (science degrees) for crime scene personnel become necessary accordingly.
- Program emphasises that to work in forensic science one must obtain a science degree.

IDENTITY

a. Course Type:

Minor/ associate degree (Group II)

b. Course Location:

Housed in department of chemistry & biochemistry

c. Relation to other courses:

offered as one (out of 12) professional option associated with the B.S. in chemistry

d. Evidence of course outcomes:

Jobs opportunities: city, county, or state laboratories, private laboratories that specialise in DNA testing, and federal agencies which conduct forensic work on food and pharmaceuticals.

e. Relationship to external authorities:

- Degree certified by the American Chemical Association
- Curriculum is run in association with the American Academy of Forensic Science

f. Other attribute(s) to identity:

- Program emphasises that 'jobs like those depicted in C.S.I. don't exist'; therefore the program recommends that students have realistic expectations before diving in.
- Program includes internship that students must apply for, a police check and background investigation must be made

before acceptance into the internship and before practicing a forensic science career.
- The public major exposure to forensic science is through media principally T.V. shows such as C.S.I.
- There is no obligation to be a police officer to practice forensic science (U.S.A); however, some federal police agencies require that lab personnel be special agents.

Comments: This course is a Group II course. It is a very chemistry-centred course with appreciation of biology (adoption of DNA techniques in forensic science). It has a strong practical work component through lab-work and obligatory internship. This program points out the disagreement on whether a science degree must be a prerequisite for forensic field practice. This program also emphasises the negative impact of media on general public in two respects: creating unrealistic expectation of what a forensic scientist does, and contributing in public confusion between the two terms: criminology and criminalistics.

Group III/ Course Code: FOR-715

KNOWLEDGE

a. Curriculum nature and organisation

Curriculum organisation is interdisciplinary where it covers a range of core sciences needed to strengthen forensic investigation and crime scene examination in the first two years, and then integrate various disciplines under the forensic science headings in the third year. It adopts an integrated approach to the development of skills in scientific investigation and forensic interpretation. Curriculum provides a core program in the first two years (chemistry, biomedical sciences, and forensic science) and then in the third year offers a more in depth specialisation in one of the below mentioned areas in addition to law. The curriculum offers a one year work placement between the second and third year (sandwich program). This enables students to acquire valuable experience and enhances their career prospects.
Prerequisites: Science foundation year including chemistry and math is desirable.

Program offers specialisations in 3 selected areas of forensic investigation through its final year:

- Chemistry with Pharmaceutical and Forensic Science
- Forensic and Medical Sciences
- Forensic Science

b. Knowledge fields in course

Course Structure: F 8, C 7, B 9, L 3, M 1, O 1.

c. Teaching approaches and curricular activities adopted in course delivery

Teaching strategies includes lectures, laboratory practicals, coursework, case reports, workshops, small-group tutorials and directed private study: directed reading, web-based searching and report writing. Teaching approaches emphasise activities that incorporate PBL and stress critical thinking.

d. Assessment practices

Assessment of the understanding of subject knowledge takes place through:
- A combination of written examinations: constructed-response questions, numerical questions, and selected-response questions (including multiple-choice questions).
- Coursework reports, case analysis, case presentations and project/ dissertation work.
This assessment is done together with problem-solving exercises to assess core academic skills.

e. Connections between knowledge fields and curriculum components

The program aims to: 1) develop professional skills which underpin life-long learning, 2) provide comprehensive knowledge and system understanding of disciplines involved: chemistry, biomedical sciences, and forensic investigation and interpretation, 3) develop team-working and autonomous learning abilities through directed study, practical forensic investigation and project work, 4) develop and demonstrate critical thinking and interpretive skills through independent investigation of a forensic topic and the underlying sciences, 5) provide the knowledge and skills needed to continue further studies in specialised forensic areas or multi-disciplinary areas involving chemical and biomedical sciences, 6) identify and define complex problems and apply appropriate knowledge and skills to their solution, 7) integrate data and concepts for a given purpose and formulate solutions to problems which recognise the uncertainty, ambiguity and limits of knowledge, and 8) present scientific information and sustaining arguments clearly and correctly in writing and orally to a range of audiences (e.g. public, judges, jury, etc). These aims are met through subjects' content; through the 1 year workplace learning experience where students are placed within a real life context and are exposed to real life situations, problems, and tasks; and through teaching strategies which adopts PBL in various situations to develop students' problem solving skills and critical thinking.

f. Other attribute(s) to knowledge:
- Course defines forensic science as a field which includes every branch of science (chemistry, biology, physics and mathematics), derived sciences (medicine, engineering, etc), many aspects of humanities and arts (psychology, law, etc), and vocational applications (photography, reconstruction, etc).
- The program develops transferable skills in both scientific and non-scientific employment to prepare students meet the needs of the professional forensic and police sector employers.

PRACTICE

a. Place of forensic practice in course:
Both within university (laboratory work) and through workplace learning (internship).

b. Extent of practice:
Program offers the option to spend a full year developing skills in a working environment (internship in the Honours year) where students:

- Apply knowledge and skills in work environment
- Develop new knowledge and skills in relevant areas of work
- Demonstrate communication skills in analysing and presenting results in writing and orally.
- Demonstrate good-time management skills and motivation in working independently and as a part of a team to meet deadlines.

c. Pedagogical practice: Students develop and demonstrate critical thinking and interpretive skills through independent investigation of a forensic topic and the underlying sciences, identify and define complex problems and apply appropriate knowledge and skills to their solution; integrate data and concepts for a given purpose and formulate solutions to problems which recognise the uncertainty, ambiguity and limits of knowledge, and present scientific information and sustaining arguments clearly and correctly in writing and orally to a range of audiences.

d. Practitioners' participation in course delivery:
Participation is major through uniquely forensic subjects and through internship.

IDENTITY

a. Course Type:
Major undergraduate- Group III

b. Course Location:
Housed in department of chemical & forensic sciences

c. Relation to other courses:
Stand-alone course

d. Evidence of course outcomes:
Professional forensic and police sector employment opportunities.

e. Relationship to external authorities:
Program offers work-related research of importance to the police and forensic professions

f. Other attribute(s) to identity:
-Defines forensic science as a domain which includes pure sciences, derived sciences, humanities, arts and vocational applications.
-Program offers specialisations in 3 selected areas of forensic investigation in the final year of the course.

Comments: This forensic science course integrates in an interdisciplinary manner areas of chemistry (analytical chemistry, spectroscopy, biochemistry, etc), biomedical sciences (genetics, cell biology, molecular biology, etc), uniquely forensic science applications (crime scene investigation, analysis of physical evidence, etc), and law (legal process, criminal law, law of evidence, etc). Proportion of chemistry, biology and uniquely forensic science subjects is approximately 1:1:1. There is emphasis throughout the program on critical thinking, presentation competencies (writing and oral), and learning in the workplace. This program reveals several teaching and assessment methods and strategies.

Group III/ Course Code: FOR-558

KNOWLEDGE

a. Curriculum nature and organisation

The curriculum covers: general education subjects, forensics core subjects, and specialisation subjects. Program offers 4 major concentrations: crime scene investigation, fire and arson investigation, forensic science, and forensic pathology. The program follows an interdisciplinary approach.

b. Knowledge fields in course

Course Structure: F 21, C 5, B 4, M 1, L 2, and O 10.

c. Teaching approaches and curricular activities adopted in course delivery

Program is delivered through classroom instruction and interaction, hands-on laboratory skills, and practicum experience.

d. Connections between knowledge fields and curriculum components:

This program aims to offer students:

-Scientific methodology, divergent problem solving strategies, critical thinking, problem-based setting framed by forensics, and basic investigative skills which prepare them for entrance into a career as an investigator and/or crime scene technician.

-Competencies and specialised skills to recognise, properly document, collect, preserve, identify and examine forensic evidence.

The course approaches its aims through integrating chemistry, natural sciences, and criminal justice within a heavy forensic focus (e.g. fingerprinting, crime scene, etc). It offers students on-campus learning (problem based settings such as. mock-up homicide scenes and moot court lab), conference participation, participation in close-knit group (student with same uniform and forensic badge), analysis of cold cases, and actual field experience (senior students called up to attend and assist law enforcement officers in real crime scenes e.g. diagramming and photographing).

PRACTICE

a. Place of forensic practice in course:

Within university and in collaboration with local enforcement agencies.

b. Extent of practice:

Laboratory, mock crime scenes, and practicum experience through re-study and re-analysis of real cold cases with local enforcement agencies.

c. Pedagogical practice:

The program emphasises hand-on training, crime scene processing competencies (recognition, documentation, collection, preservation, identification and examination of evidence), and specialised skills in crime investigation (drugs, homicide, sex offences, etc). Program offers opportunities to learn craft- from grave digs to mock-ups of homicide scene. Program offers senior level students to work with local enforcement agencies on cold cases that are 5-30 years old.

d. Practitioners' participation in course delivery:

Major contribution in the delivery of uniquely forensic science subjects, in working with students on analysing cold cases, and in supervising senior students in the crime scene.

IDENTITY

a. Course Type:

Major Undergraduate- Group III

b. Course Location:

Administering department: school of arts and sciences

c. Relation to other courses:

Stand- Alone Course

d. Evidence of course outcomes:

Career opportunities revealed by this program are state and federal forensic jobs (U.S.A) including: crime scene investigator, fingerprint technician, photographer, evidence technicians, homicide investigator, food and drug inspector.

e. Relationship to external authorities:

Relation to local enforcement agencies.

f. Other attribute(s) to identity:

-Forensics is a young science and profession; however, it is a dynamic one and a growing field which is spurred by new technologies, increased use by law enforcement, jury expectations, and new legal requirements.

-The popularity of forensics-related TV shows, along with great prospects for employment, makes this a popular major.

- Program suggests that up to 10,000 jobs will be available in forensic science in the next 10 years.

- Program offers 4 major concentrations.

Comments: This is a group III course which incorporates a very heavy forensic practical component. The curriculum includes general education core, forensics core and concentration core: C.S.I, Fire and arson investigation, forensic science (laboratory technician) or forensic pathology. This program possesses very strong connections with the industry stakeholders. It has arrangements in place which allow senior students to accompany forensic science practitioners to real crime scenes.

Group III/ Course Code: FOR-766

KNOWLEDGE

a. Curriculum nature and organisation

This program adopts a multidisciplinary curriculum to organise forensic science knowledge. In the first year, students would gain a sound foundation in chemistry, forensic methods, biology and the national legal system. Second year includes statistics for forensic science, experimental data analysis, analytical chemistry and molecular biology. Third year stresses forensic methods, including DNA fingerprinting, trace analysis (in soils, hairs, fibres etc), and environmental analytical chemistry. Forensic methods are taught in second and third years. Students are introduced to the legislative and professional background of forensic and analytical chemistry from first year onwards, including issues such as occupational health and safety, quality assurance and environmental legislation.

Prerequisites of course: year 12 with chemistry as a requirement and physics year 12 is recommended.

b. Knowledge fields in course

Course Structure: 7 F, 17 C, 3 B, L1, M 3, O 1.

c. Connections between knowledge fields and curriculum components

This program aims to graduate students with a detailed general knowledge background of all aspects of chemistry with emphasis on the methods and techniques relevant to analytical chemistry and their applications to forensic chemistry. Graduates will also possess a basic knowledge of supporting areas associated with forensic science, such as biology, earth sciences and physics. Upon graduation students will also possess communication skills (oral and written) and understanding of ethical issues associated with forensic science practice. Program meets its objectives by the curriculum organisation and course structure which incorporate both a heavy chemistry component and a specialised molecular biology (DNA) component. Course also stresses ethical and legal issues. Course exposes students to the various forensic methods and applications within university and through internship.

PRACTICE

a. Place of forensic practice in course:

Within university and through internship.

b. Extent of practice:

Both in laboratory work at university and through internship at a forensic or analytical chemistry laboratory (internship takes place through the second year). A key feature of the degree is the industrial work experience that is undertaken through the internship.

c. Pedagogical practice:

Projects will be undertaken by students each year. These projects involve solving real analytical and forensic problems.

d. Practitioner participation in course delivery:

Some of the lectures within specific subjects are offered by practitioners and expertise in the field (e.g. state forensic experts, police members, etc).

IDENTITY

a. Course Type:

Major undergraduate- Group III: Bachelor of Technology (Forensic and Analytical Chemistry).

b. Course Location:

Administering department: faculty of science and engineering

c. Relation to other courses:

Strongly related to chemistry courses (incorporates a heavy analytical chemistry component).

d. Evidence of course outcomes:

Career opportunities for graduates cover employment in chemical, pharmaceutical, food, and forensic laboratories (forensic chemists). All of the graduates of this course have gained employment in the Australian Federal Police, marine chemical investigations, and in forensic, analytical, food science (winery), and environmental laboratories.

e. Relationship to external authorities:

This course is offered in collaboration and consultation with state police department, state forensic science centre, the federal police, and a national association of forensic science. Graduates are accredited to practice as analytical chemists by a national accreditation body of chemistry.

COMMENTS:

This is a heavy chemistry (analytical chemistry) course with sound forensic subjects. The course mainly focuses on the analytical chemistry applications in solving forensic problems and also focuses on DNA in the forensic applications. It also stresses legal and ethical issues throughout course delivery. The strong correlation with the national body for chemistry accreditation, state forensic science centre and state police department is reflected through the course's aims, curricular activities (projects, seminars, and practicum), structure and content. This program embraces within its subject career- oriented competencies including preparation of curriculum vitae, addressing selection criteria and application to mock jobs through mock interviews in order to understand what do employers want, need and acquire. This course emphasises that a science degree is a prerequisite for any employment within the forensic laboratories.

Group III/ Course Code: FOR-709

KNOWLEDGE

a. Curriculum nature and organisation

Course is multidisciplinary in some specialisations and interdisciplinary in others. The core scientific content of this course is taught through the school of physical sciences, department of biosciences, and the law school (to provide legal background).

The first year of the program provides students with broad base of knowledge on which forensic science is founded.

This Program offers a bachelor of science (Hon) in 4 specialised majors:

- Forensic Science: offers a general approach to science alongside an understanding of key legal topics.
- Forensic Chemistry: emphasises strongly on chemistry; however, it maintains the integration of scientific skills within a legal context.
- Forensic Science with physics emphasis: combines physics with forensic science to illustrate some of the specialised techniques and analytical skills needed by forensic scientists, such as digital recognition, finger-printing, ballistics and weapons.
- Forensic Biology: provides a strong basis in biosciences and progresses to the understanding and application of forensic biology techniques. It allows the integration of biology, law and forensic science.

b. Knowledge fields in course

Course Structure:

- Forensic science course and forensic chemistry course have nearly the same curricular structure: F7, L3, C8, 5, M1 (statistics emphasis).
- Forensic Biology: F 6, L3, C1, B11.

Within the program one of the offered subjects stresses presentation skills for forensic science in report writing, statement preparation, and courtroom presentation.

c. Teaching approaches and curricular activities adopted in course delivery

In addition to lectures, laboratory classes, tutorials, workshops, self-learning packages, there is indication of PBL through problem-solving sessions.

d. Connections between knowledge fields and curriculum components

The program aims to integrate the scientific skills within a legal context and offers options of emphasis in pure sciences as well: chemistry, biology, etc. The program approaches its aims by integrating its program within three departments: school of law, school of physical sciences and department of biosciences where every subject is taught by the relevant school. In addition the program offers 1 year industry placement.

PRACTICE

a. Place of forensic practice in course:

Both within university (lab) and outside (1 year industry placement)

b. Extent of practice:

Program offers within its 4-years duration a one-year placement in industry, where the student is guided by an academic supervisor and industrial supervisor that consult with one another. During this year the student would gain experience, salary, and employment prospects for after graduation. The student will report his/her 1-year placement experience in his/her final year and will present a lecture as well. This year counts towards degree completion.

c. Pedagogical practice:

Workplace learning and practice-based learning.

d. Practitioners' participation in course delivery:

Major contribution in uniquely forensic science subjects and through 1 year placement in industry

e. Other attribute(s) to practice:

In Germany, medical practitioners attending crime scene also participates in the processing of the crime scene. These roles are clearly separated in other countries like in the U.K. and Australia.

IDENTITY

a. Course Type:

Major Undergraduate- Group III

b. Course Location:

Forensic science and forensic chemistry are located in the school of physical sciences. Forensic biology is located in department of biosciences.

c. Relation to other courses:

Course is offered within more than one school: the school of physical sciences, department of biosciences, and the law school (to provide legal background).

d. Evidence of course outcomes:

Career opportunities: Government agencies, consultancies, emergency services, local authorities, contract laboratories.

e. Relationship to external authorities:

- Program has strong collaborative links with forensic science services, local health authorities, biotechnology companies, chemical companies, and pharmaceutical companies within UK and Europe.
- Professional recognition: Subjects that are taught in this program are recognised by related bodies of specialisations for example, Forensic Science Society, Law Society (for Law component within the program) and same applies for chemistry and biosciences incorporated within the course.

f. Other attribute(s) to identity:

-Program reveals that forensic science is a high profile subject in U.K.

-Forensic scientists are specialists; however, their skills have to bridge several disciplines.

- This Program offers a bachelor of science (Hon) in specialised majors as follows: forensic science, forensic chemistry, forensic biology, and forensic science with physics emphasis.
- Program emphasises that up until the last two decades, most of forensic science practice relied on chemistry and used the various analytical chemical techniques in developing its work. In the last two decades, spectacular advances have been made at the frontiers between disciplines, greatly increasing the understanding of the biochemical workings of living organisms, the chemical basis of reproduction and heredity, nature of disease, and the human genome. This introduced more biology and biochemistry within forensic science practice.

Comment: This program offers various specialisations: Bachelor of Science in: Forensic Science, Forensic Chemistry, Forensic Biology, Forensic Science with Physics Emphasis. The forensic science programme offers a general approach to science alongside an understanding of key legal topics. The forensic chemistry programme puts a stronger emphasis on the study of chemistry, but maintains the integration of scientific skills within a legal context (forensic science subjects). The forensic Biology has a very heavy bioscience component but also maintains the integration of scientific skills within a legal context (forensic science subjects) All these three specialisation have the same amount of law component. There is emphasis on the communication skills of evidence analysis in reports, statements, and at courts. Course also emphasises numeracy skills and statistics within its curriculum.

Group III/ Course Code: FOR-754

KNOWLEDGE

a. Curriculum nature and organisation

This program provides options to have a 3 years degree, or a sandwich 4-years degree with 1 year of placement in industry. The program is based and predominantly taught in the school of bio-molecular sciences, in addition to heavy contributions from school of biological and earth sciences and the school of pharmacy and chemistry. A few modules have also been contributed by school of law and school of art and design.

Entry requirements: year 12 including Maths and English.

Program offers various specialisation BSc (Hon):

- Forensic science: BSc
- Biochemistry and forensic science
- Forensic science and biological anthropology (joint award)
- Psychology and forensic science
- Forensic science and criminal justice (joint award)

Forensic science & criminal justice degree is established due to the complementary nature of forensic science and criminal justice. It possesses an interdisciplinary approach to issues pertaining to both of them. Forensic science emphasises a rigorous quantitative approach and lateral thinking, whilst criminal justice emphasises logical thinking and accuracy of expression in the spoken and the written word.

b. Knowledge fields in course

Course Structure: F 8, C 6, B 13, P 1, L 2.

c. Teaching approaches and curricular activities adopted in course delivery

Course delivery includes lectures, practicals, and tutorials in proportions as appropriate to the subject matter.

d. Connections between knowledge fields and curriculum components

Program connects knowledge fields and curricular component by offering a number of specialisations within forensic science and through offering one year placement in industry or foundation degree which backs up students with necessary vocational higher education.

PRACTICE

a. Place of forensic practice in course:

Mainly within university with the option of one extra placement year within industry (4- year sandwich degree) or foundation degree (4 or 5 years).

b. Extent of practice:

Program gives the option for students in registering for a 4-year sandwich degree (or just complete the degree in 3 years), where the third year is spent in professional training placement (e.g. police forces). Program offers a foundation degree which is a vocational higher education qualification combining academic study with work-based learning. This placement allows students to both gain experience of working and widen scientific training.

c. Practitioner participation in course delivery:

Practitioner (police, forensic practitioner, etc) participates in course delivery in the uniquely forensic subjects and through the foundation year (placement year- as part of 4-years sandwich degree).

IDENTITY

a. Course Type:

Major Undergraduate- Group III

b. Course Location:

Administering Department: School of Bimolecular Sciences.

c. Relation to other courses:

Heavy contributions take place from the school of biological and earth sciences and the school of pharmacy and chemistry. A few modules have been also contributed by school of law and school of art and design.

d. Evidence of course outcomes:

Career opportunities are generally through public and private laboratories and forensic science services

Due to the severe competition for forensic science jobs, the program provides a “fall-back” position for students who would like to pursue a different career, e.g. molecular biologists.

e. Relationship to external authorities:

The program maintains good association with state police and with other forensic science providers through various aspects one of which is their provision of industrial training places during the 3rd year.

f. Other attribute(s) to identity:

-Traditionally, forensic science laboratories were government owned and mainly served the police and the prosecution service. Now semi-independent government agencies started emerging; however, the majority of the forensic science services are still provided by police departments.

- Honours degree is the minimum requirement for jobs such as forensic scientists or researchers in laboratories.

- Program offers various specialisations BSc (Hon): Forensic science, biochemistry and forensic science, forensic science and biological anthropology (joint award), psychology and forensic science, and forensic science and criminal justice (joint award).

- Generally police crime scene investigators are trained 'in service' and do not require a university degree, although progressively graduates do apply for CSI jobs.

Comments: This program encompasses contributions from various disciplines: biology, chemistry, law, etc… The program emphasises the integration between chemical and biological analytical techniques to serve forensic analysis. The heaviest emphasis in this program comes from the bio-molecular sciences and biochemistry subjects; hence, the program is placed in the bio-molecular science department.

Group IV/ Course Code: FOR-762

KNOWLEDGE

a. Curriculum nature and organisation

This is an interdisciplinary program. The program offers various postgraduate degrees: Graduate Diploma, Master and Master's-PhD of forensic science. The programme consists of both coursework and research. The programme exposes students to a broad range of disciplines that carry the potential for significant practical application. Students with honours degree will be able to apply for the Master's-PhD degree. The Master's-PhD course is spread over 4 years of PhD candidature and the student graduates with a Master's of forensic science and a PhD in their chosen discipline (biochemistry, chemistry, biotechnology, etc).

b. Knowledge fields in course

- Within the curriculum there is a law component. This component of law (instructed by faculty of law) is specifically designed to enable students to understand both criminal justice and the process of presenting evidence as an expert witness within a courtroom.
- Research projects within Master's degree will be discipline-based and problem-based and conducted under the supervision of one or more academic supervisors.
- As for course structure there is a research component and a core component. The core component contains 12-13 subjects most of which are forensic subjects associated with disciplines (e.g. chemistry, imaging, botanical evidence, soil evidence, microscopy, DNA). This is because the program assumes that essential scientific disciplines would have already been covered through the undergraduate level. The research component (e.g. Master's level) will include a case study and a research thesis component. The case study will include scientific research, law and the presentation of evidence. Students will be required to review and critically analyse evidence within the context of their research into a historic case in law where forensic evidence has been presented to establish a prosecution or uphold defence. The students will be required to analyse this evidence, take steps to repeat the analytical process where possible constructing a hypothetical case related to their historical case, which will be derived from the units they have undertaken in the course and also from their supervised case study. As part of this unit, students will be required to attend lectures on criminology and expert evidence. Students will also attend a live court case and write a report on this court case. The hypothetical case will be presented within a mock court. In the research thesis students are required to undertake a supervised research in a topic of an applied or fundamental nature but in either case it is expected that results will have a bearing on forensic science.

c. Teaching approaches and curricular activities adopted in course delivery

Lectures and workshops will contain a combination of theoretical material, enabling students to make judgements on the veracity of scientific evidence, and sufficient practical experience of techniques in order to evaluate and apply analytical processes. The opportunity exists, within the research component of the Master's degree, for students to become proficient in one or more areas of specific expertise. Research projects will be discipline-based and problem-based and conducted under the supervision of one or more academic supervisors.

Part of the research component of both the Diploma and Master degrees will be a critical case study, which will involve research into forensic evidence, documentation and law. Finally, as part of this section of the course, students will be expected to display evidence of proficiency within a mock courtroom before members of the legal profession.

d. Connections between knowledge fields and curriculum components

The programme consists of both coursework and research. The program exposes students to a broad range of disciplines that carry the potential for significant practical application. Students will gain hands-on experience in the analysis of material associated with a crime scene and in the use of advanced techniques (analytical chemistry, molecular biology and genetics). In addition, students will conduct experiments with animal carcasses as human models. As part of their research study, students will be required to receive instruction from the faculty of law. This law component is specifically designed to enable students to understand both criminal justice and the process of presenting evidence as an expert witness within a courtroom.

PRACTICE

a. Place of forensic practice in course:

Within university, workshops, mock-court presentations and through 4-week placements.

b. Extent of practice:

Students will employ various techniques in their analytical experiments and will use animals to represent human in mock experiments to study various aspects: decomposition process, estimating time of death, etc. Students will be expected to display evidence of proficiency within a mock courtroom before members of the legal profession.

Program has association with state police in workshops delivery and in a 4-weeks professional development program; one week of which, is spent participating in fingerprint collection and crime scene procedures at the police academy.

c. Pedagogical practice:
The programme consists of both coursework and research. The programme exposes students to a broad range of disciplines that carry the potential for significant practical application. Students will gain hands-on experience in the analysis of material associated with a crime scene and use advanced techniques (analytical chemistry, molecular biology and genetics) In addition, students will conduct experiments with animal carcasses as human models. From these experiences students will not only learn basic human anatomy but also aspects of pathology, and decomposition processes associated with estimating the time of death, all of which may be relevant to violent crime.

d. Practitioners' participation in course delivery:
Through delivery of some subjects and during the 4- week placement, each student will be rostered to a police officer and will participate in all the officers' activities as an observer. Students will analyse evidence in mock courtrooms before members of the legal profession.

IDENTITY

a. Course Type:
Group IV- postgraduate

b. Course Location:
Administering Department: Centre for Forensic Science (Stand-alone centre).

c. Relation to other courses:
Independent but there are contributions from the faculties of life sciences, physical sciences, and law.

d. Evidence of course outcomes:
Employment within forensic industry

e. Relationship to external authorities:
Police and Police academy

f. Other attribute(s) to identity:
There is a requirement of confidentiality for students as they become exposed to confidential and sensitive information, document(s), and/or casework as in their training.

Comments: This postgraduate program includes both course-work and research-work. Course work includes specialised subjects in various forensic-related topic (botany, soil, instrumentation, DNA) and includes a case study of a cold case where students bring up and reanalyse forensic evidence, comment on it, and present it in a mock court. It also includes a research thesis of topics that will have a bearing on forensic science. There is still no PhD in forensic science, it is still given under a major discipline: biochemistry, chemistry, biotechnology, etc, yet at Master's level there is a Master of Forensic Science.

Group IV/ Course Code: FOR- 554

KNOWLEDGE

a. Curriculum nature and organisation

Program adopts an interdisciplinary approach in course delivery.
Prerequisites: bachelor degree in a science discipline related to the Master's concentration.

This program offers both MSc in forensic science and Masters of Forensic Science, both with concentrations in crime scene investigation, forensic molecular biology, forensic chemistry, and forensic toxicology. The Masters of Forensic Science is offered with a concentration on high technology crime investigation and security management.

b. Knowledge fields in course

Program incorporates concentrated forensic subjects and some law and criminal justice subjects as well, and then each concentration involves the subjects of speciality of interest.

c. Connections between knowledge fields and curriculum components

The Masters of Forensic Science- coursework program- aims to provide an understanding of the integration of forensic science disciplines with the investigation of criminal activity, along with an overview of analytical methods, procedures, equipment, and data used by forensic specialists. Concentrations in specific fields are also available (forensic molecular biology, toxicology, chemistry and crime scene investigation). The aims of the program are achieved through lectures, sophisticated lab work, internship, and networking with AAFS and with specialised personnel, seminars, and conferences.

PRACTICE

a. Place of forensic practice in course:

Within university: specialised laboratories (microscopy-chemistry and biology with advanced machinery) and outside university through internship.

b. Extent of practice:

Program offers internship with state and federal police and crime scene offices.

c. Other attributes to practice:

The university established an association of forensic science students which enriches the educational curriculum for students of forensic sciences through contact with agencies and individuals with professional experience in the field (network with professionals, academic authorities, other students, and graduates).

d. Practitioners' participation in course delivery:

Major contribution in uniquely forensic science subjects and internship.

IDENTITY

a. Course Type:

Group IV- postgraduate

b. Course Location:

Administering Department: Department of forensic science (Stand-Alone Department).

c. Relation to other courses:

Stand-alone course

d. Evidence of course outcomes:

Career opportunities exist mainly within the government along various sectors e.g. FBI, Navy, and National Centre for Missing and Exploited Children.

e. Relationship to external authorities:

State and Federal Police, and AAFS.

Comments: The general Masters of Forensic Science underpins segments of every discipline in an interdisciplinary approach: chemistry, biology, law and criminal justice, knowledge of photography, examination of questioned documents, trace evidence analysis, firearms and tool mark identification. The program leading to the Masters of Science in forensic science is offered to help professionals develop an understanding of the scientific methods used in analysing evidence and apply these skills in criminal investigation. This program also offers specialisations in chemistry, molecular biology, crime scene investigation.

Group IV/ Course Code: FOR-556

KNOWLEDGE

a. Curriculum nature and organisation

- This program is designed to provide a broad-based, interdisciplinary learning experience which includes emphasis on DNA analysis, forensic chemistry and computer forensics. Both thesis and non-thesis options are available.
- Prerequisites: bachelor degree in a natural science or forensic science including one year of biology, physics, chemistry, and organic chemistry all with their associated laboratory subjects.

b. Knowledge fields in course

This graduate program is a 2-year program leading to a Master's of Science degree in forensic science. The curriculum is designed to develop an academic foundation and practical competency in a variety of forensic science fields: crime scene processing, death investigation, DNA profiling, paternity testing, computer forensics, trace evidence analysis, advanced drug analysis and testing, fire debris and arson investigation, and legal issues related to forensic science. In addition to a core selection of courses which provides broad-based educational experience in forensic science, the graduate program offers three areas of emphasis at least one of which the student must undertake: forensic DNA analysis, forensic chemistry, and computer forensics.

c. Connections between knowledge fields and curriculum components

The aims of the program are achieved within the university and through internship. In addition to a core selection of courses which provides broad-based educational experiences in forensic science, the graduate program offers three areas of emphasis at least one of which the student must undertake: forensic DNA analysis, forensic chemistry, and computer forensics.

PRACTICE

a. Place of forensic practice in course:

Within university and outside (through internship).

b. Extent of practice:

The program offers internship within both the university (as university has important facilities including CODIS laboratory) and other crime laboratories within the state or nationally. This internship is offered between the first and the second year of study.

c. Other attribute(s) to practice:

- This program argues that the success of any program is measured by the success of its graduates. Hence, because its graduates are well accommodated by the forensic science community, this program describes itself as a successful one.
- University also offers through its facilities parentage testing services.

d. **Practitioners' participation in course delivery:**

Major contribution in delivery of forensic science subjects and supervision through internship.

IDENTITY

a. Course Type:

Group IV- Postgraduate.

b. Course Location:

Adminstering Department: Forensic Science Centre (Stand-Alone Centre).

c. Relation to other courses:

Independent

d. Evidence of course outcomes:

Graduates of the forensic science program are employed by the federal police, secret service, armed forces, state and local crime laboratories, private laboratories, state bureaus of investigation, insurance agencies, and the university's CODIS laboratory

e. Relationship to external authorities:

-In 2005, program has been offered full accreditation (for 5 years) from the American Academy of Forensic Science (AAFS). This program also enjoys accreditations from forensic quality services and forensic quality services international. Program also has affiliations with national institute of justice. The university is also included in national programs.

-The university's CODIS lab is part of a national effort to connect all state police CODIS labs to the national database of federal police and this lab is partly funded from the state government.

f. Other attribute(s) to identity:

- This program describes forensic science as a rapidly evolving discipline.
- University offers through its facilities parentage testing services.
- Graduate program offers three areas of emphasis at least one of which the student must undertake: forensic DNA

analysis, forensic chemistry, and computer forensics

Comments: The history of the forensic science centre within this university goes back to 1989 where the first DNA typing case in the state took place within the university. As a response to meeting the growing needs of forensic scientists and to educate police members about DNA and new technologies, the program has been approved and commenced in 1994, when graduate level courses were first offered to the state police officers as part of their continuing education program. This program emphasises that in the past forensic laboratories were staffed primarily with graduates of chemistry and biology and the 'forensic where acquired through in-service training once these graduates are hired. However, nowadays (as argued by the program) due to the increased introduction of scientific results into court testimony and the demands for formal training which includes hands-on experiences, more forensic science programs- one of which is this program- aim to produce forensic scientists who can immediately enter the workforce with a solid foundation in forensic science, in attempt to reduce in-lab training period.

Group V/ Course Code: FOR-706

KNOWLEDGE

a. Curriculum nature and organisation

- Program is interdisciplinary in nature.
- Offers undergraduate & postgraduate degrees :

1) Bachelor of science degrees (various majors, e.g. Forensic Science, Police and Criminal Investigation, Forensic Biology, Forensic Chemistry, Forensic Science & Criminal Investigation, etc), Honours, Foundation Degree, and
2) Master's of Science (various Specialisations: DNA profiling, Forensic Anthropology, Document Examination).

-Bachelor of forensic science comprises 5 main streams over 3 year full time study, one of which is obligatory. The obligatory stream comprises education and training in the management and processing of crime scenes, the collection and analysis of evidence from crime scenes (forensic photography, processing, fingerprinting, footwear impressions, hairs and fibres, glass fragments, tool marks in laboratory) and law for forensic scientists. As for the remaining four optional streams which complement the core module in forensic practice and investigation, the student may elect to study at least two of these in the 2nd and 3rd years of the course. The optional streams are: forensic biology, forensic chemistry, forensic anthropology, and fire investigation.

- BSc in Police and Criminal Investigation has been designed to equip graduates with knowledge and skills relevant to careers as crime investigators within the police service and other investigation agencies. The course provides education and training in investigative and policing skills and in the complementary areas of forensic science, criminal law and criminology or psychology.

-The Bachelor of Science (Hon) in forensic science and criminal investigation combines all, law (sources of law, domestic and international criminal law, etc) and policing (criminal investigation, interviewing techniques, etc) with forensic science (criminalistics, forensic biology, forensic chemistry, etc).

- The MSc in DNA profiling is a 1 one year- 3 semesters course: 2 of which are taught modules and the third is an independently undertaken research project. This course caters for both graduate students and forensic practitioners. This course will focus on the fundamentals of molecular genetics that underpin the discipline of DNA profiling. Students will have the opportunity to undertake simulated cases from the analysis of the evidence through to the DNA analysis and the presentation of a written report (subject: expert witness communication). The course will develop theoretical knowledge and practical application of the key aspects of forensic DNA profiling. While the course focuses on forensic applications the skills developed will also be transferable to different types of diagnostic DNA typing. The course will also provide the opportunity to develop key transferable skills including research techniques, critical analysis of written material, and communication skills.

- The MSc in Document Examination is designed to enable graduate students and forensic practitioners to understand and develop the theoretical knowledge underpinning all aspects of forensic document examination. Modules of the course include the scientific analysis of handwriting and signatures in a forensic context. This course will provide intensive training and practical experience in the examination of printing equipment, typewriters, photocopiers and the identification of forged or counterfeit documents. Students will also be trained in a number of forensic techniques using highly specialised apparatus, such as the visual spectral comparator, comparison microscope, the ESDA (Electrostatic Detection Apparatus) technique and Raman Spectrometer

b. Knowledge fields in course

Course Structure (BSC in Forensic Science): F 8, C4, B4, L1, O1.

Course Structure (BSC in Forensic Biology): almost balances between forensic and biology subjects, whilst more focused on forensics with the complementing biology courses (subject ratio: B10: F9).

c. Teaching approaches and curricular activities adopted in course delivery

It is delivered through lectures, tutorials, seminars, practical sessions, crime scene simulations, laboratory applications and courtroom experience. In addition to covering the law relating to forensic science, students also present evidence in a moot courtroom under cross-examination.

d. Assessment practices

Assessment includes formal examinations, essays and other written assessments, projects, class presentations of cases and a research project dissertation. Students are also required to present evidence in a moot courtroom under cross-examination.

e. Connections between knowledge fields and curriculum components

The program aims at the undergraduate level to: 1) develop students' skills in communication both verbally and in writing, 2) develop their critical and analytical mind, 3) develop their practical skills in the underpinning forensic sciences: biology and chemistry, 4) develop the necessary skills which allows them to carry out a forensic investigation, 5) provide them with detailed contextual knowledge of subjects underpinning forensic science in the broad areas of biology, chemistry and investigation, 6) provide students with the necessary skills to carry out independent research projects. Program provides students through its curriculum contacts with the forensic science service providers, constabularies, and other forensic practitioners to aid them in developing their future career opportunities. The program approaches its aims by traditional teaching methods &work-based learning within university and through the compulsory foundation year prior to graduation.

At the postgraduate level: The MSc programmes have been designed to provide an in-depth study of a particular topic (e.g. forensic anthropology and DNA profiling) and to develop the critical and analytical skills involving the principles, practices and techniques of that specialist topic (theoretical knowledge and practical applications). In addition, the students will acquire research method skills and presentation skills. Program aim to develop students' skills in solving problems either independently or as a team member will be developed to a level commensurate to the master's level. The master's course is a one year course taught across three semesters. The first two semesters are delivered as taught modules and the third semester consists of an independently undertaken research project. The course is designed for both graduate students and forensic practitioners.

PRACTICE

a. Place of forensic practice in course:

Within university, through vocational training (on site practice), and through foundation training (which addresses the demands of employers for higher education).

b. Extent of practice:

The foundation year degree in forensic science has been developed through a partnership between employers, colleges and the Department of Forensic & Investigative Science. This degree uses forensic science as a vehicle to teach science and laboratory based skills in a vocational setting.

c. Pedagogical practice:

Foundation year provide vocational setting which emphasises on employability and key skills such as problem solving, critical thinking, written and verbal communication. Upon successful completion, student will be allowed to progress to the final year of the B.Sc. (Hons) degree in forensic science, which improves chances of employability.

d. Practitioner participation in course delivery:

Many of the staff members delivering the course have firsthand experience of forensic investigation and policing allowing modules on the courses to be delivered with the benefit of that experience.

IDENTITY

a. Course Type:

Group V- Undergraduate & Postgraduate

b. Course Location:

The Department of Forensic & Investigative Science (new initiative by the university)

c. Evidence of course outcomes:

-BSc in Police and Criminal Investigation: This course emphasises career opportunities which are very relevant to investigative careers with services such as the Military Police, H.M. Immigration Service, H.M. Customs and Excise, Post Office Investigations, NHS Counter fraud, private insurance consultancies and fraud industries investigators.

- BSc (Hon) in Forensic Science and Criminal investigation: This course emphasises national and international employments in private and public sectors such as crime scene officer, forensic scientist, police, analytical chemist, toxicologist, insurance claim officer, industrial research scientist, occupational hygienist, patent examiner, immigration service, customs and excise, transport police (securing transport of people and goodies), health and safety inspector, environmental health officer, and trading standard officer.

d. Relationship to external authorities:

Forensic Science Service & Forensic Science Society

e. Other attribute(s) to identity:

- Offers Various Specialisations at the undergraduate and postgraduate levels.
- The Bachelor of Science in Police and Criminal Investigation is the first of its kind in the U.K.
- Criticism for unrealistic image generated by media forensic shows: Bones, C.S.I., etc.
- This program offers a Master's of Science degree in document examination which is emphasised by the university to be the only taught programme in academia, where students will study the principles underpinning the scientific analysis of handwriting and signatures together with the considerations involved when carrying out forensic casework.
- In Scotland forensic science services are still maintained by local police forces; however, some private laboratories are competing with traditional providers.

COMMENTS:

Comments: This Program offers forensic science degree on both the undergraduate and postgraduate level in addition to non-award certificates. As for the undergraduate level there is room for specialising in depth in forensic investigations complementing with supporting studies such as biology, chemistry, anthropology, and fire investigations. The program also offers a general forensic science course with a more specialised policing study and offers a one year work placement in a 4-year degree (Placement takes place in the third year). This program delivers combined degrees where forensic science can be combined with other disciplines: biology, law, psychology, journalism, etc. Postgraduate studies (Master's of Science) are open to both graduate students and forensic practitioners.

Group V/ Course Code: FOR-757

KNOWLEDGE

a. Curriculum nature and organisation

Program is multidisciplinary in nature and offers both undergraduate and postgraduate courses.

As for the undergraduate courses, this provider offers three undergraduate degrees in forensics:

1. **BSc biomedical science- forensic science:** This course provides a firm foundation in biomedical sciences and their applications to forensic investigations of human evidence. This course brings together extensive theoretical knowledge with advanced laboratory and problem-solving skills in forensic and biomedical science. Prerequisites: assumed knowledge in English, mathematics, chemistry and physics.

2. **BSc in environmental forensics:** This course offers the new and fast-developing discipline of environmental forensics that is integral to the processes of environmental protection. It involves the study of both living and non-living components of the environment, and impacts of human use of environmental resources on the ecosystem function. The course adopts a multidisciplinary approach that allows students to acquire competencies and knowledge through theoretical and practice-based field and laboratory studies of ecology and environmental chemistry, and to understand the importance of investigatory scientific evidence in the legal and regulatory framework that governs the environmental protection process. Graduates will have gained scientific training and an understanding of the legal framework underlying environmental protection. This cross-disciplinary course combines all of environmental biology, chemistry and law with gives a choice of further specialisations, ecosystem studies, analytical chemistry or molecular biology. Prerequisites: assumed knowledge in mathematics, English and a science subject.

3. **BSc (Honours) in Applied Chemistry- Forensic Science:** This course aims to prepare students for entry to professional work in the field of applied chemistry or as specialists in the forensic science area. It includes a foundation in the basic sciences, with in-depth development of chemistry and analytical sciences and forensic techniques, emphasising forensic applications. It also includes a compulsory Honours program to develop research and forensic skills. This course aims to produce professional forensic scientists and chemists with highly adaptable and practical scientific skills, accompanied by a thorough grounding in theory. Prerequisites: assumed knowledge in mathematics, physics, and chemistry.

As for Postgraduate degrees it is offered as research degrees (MSc or PhD) by research in one of the following areas:

fingerprints, questioned documents, trace evidence, fire investigation and analysis, illicit drugs, toxicology, DNA profiling, materials and engineering, statistics and data handling, and artificial neural network applied to forensic classification. The degree is awarded as a Master's of Science or PhD in science depending on the discipline (s) followed to answer the research question (chemistry, biology, physics, engineering, computer science, or maths, etc)

b. Knowledge fields in course

-BSc biomedical science- forensic science: Course Structure: F5, C2, B9, M1, P1, L1

-BSc in environmental forensics: Course Structure: F2, B2, C2, L1, M2, E5.

-BSc (Honours) in Applied Chemistry- Forensic Science: Course Structure: F10, C11, B2, M2, P2, L2

c. Connections between knowledge fields and curriculum components

The **Applied Chemistry- Forensic Science course** aims to produce professional forensic scientists and chemists with highly adaptable and practical scientific skills, accompanied by a thorough grounding in theory. This aim is achieved through a very heavy chemistry component accompanied with concentrated forensic component delivered through lectures, laboratory work and computer-based teaching.

The **BSc in environmental forensics course** aims to produce professional environmental scientists with a solid scientific background in environmental protection, thereby enabling them to contribute to environmental management, policy and planning processes. Graduates gain scientific training and an understanding of the legal framework underlying environmental protection. The course achieves its aim through a heavy science (chemistry- ecology) component with emphasis on forensic applications.

The **BSc biomedical science- forensic science course** aims to provide a firm foundation in biomedical sciences and their applications to forensic investigations of human evidence. The program achieves its aims through a heavy biological-biomedical component which brings together extensive theoretical knowledge with advanced laboratory and problem-solving skills in both forensic and biomedical science.

PRACTICE

a. Place of forensic practice in course:

Mainly within the university with sufficient facilities to cater for various forensic science activities and practicum.

b. Extent of practice:

Chemistry, analytical sciences, and forensic techniques which emphasise forensic applications. It also includes a compulsory Honours program to develop research and forensic skills.

c. Pedagogical practice:

Program exposes students to practice through mock up crime scenes and court presentations and exposes its honours and postgraduate students to facilities at the forensic science agencies during their research journey.

IDENTITY

a. Course Type:

Group V- Undergraduate & Postgraduate

b. Course Location:

This course is housed within department of chemistry for forensic chemistry and within department of cell and molecular biology for forensic biology

c. Relation to other courses:

Forensic chemistry is strongly linked with chemistry and forensic biology is strongly lined with biological sciences.

d. Evidence of course outcomes:

- BSc biomedical science- forensic science: emphasises career opportunities such as forensic laboratories, private DNA testing laboratories, law enforcement agencies, government departments, hospitals and medical pathology laboratories.

- BSc in environmental forensics: emphasises career opportunities such as environmental analysts and consultants, environmental scientists, planners and policy advisers in government and private industries in environment protection and natural resource. Graduates can also develop careers in teaching or in research.

- BSc (Honours) in Applied Chemistry- Forensic Science: emphasises career opportunities such as forensic chemists, police service, private investigation, environmental chemistry, and drug detection.
- Graduates are in high demand for employment in forensic laboratories, private DNA testing laboratories, law enforcement agencies, government departments, hospitals and medical pathology laboratories.

e. Relationship to external authorities:

Program has strong links with federal and state police services and government forensic laboratories. Course is recognised by the national forensic science association. In addition, forensic chemistry graduates are accredited as chemists by the national accreditation body for chemistry.

f. Other attribute(s) to identity:

Various specialisations at both undergraduate and postgraduate levels.

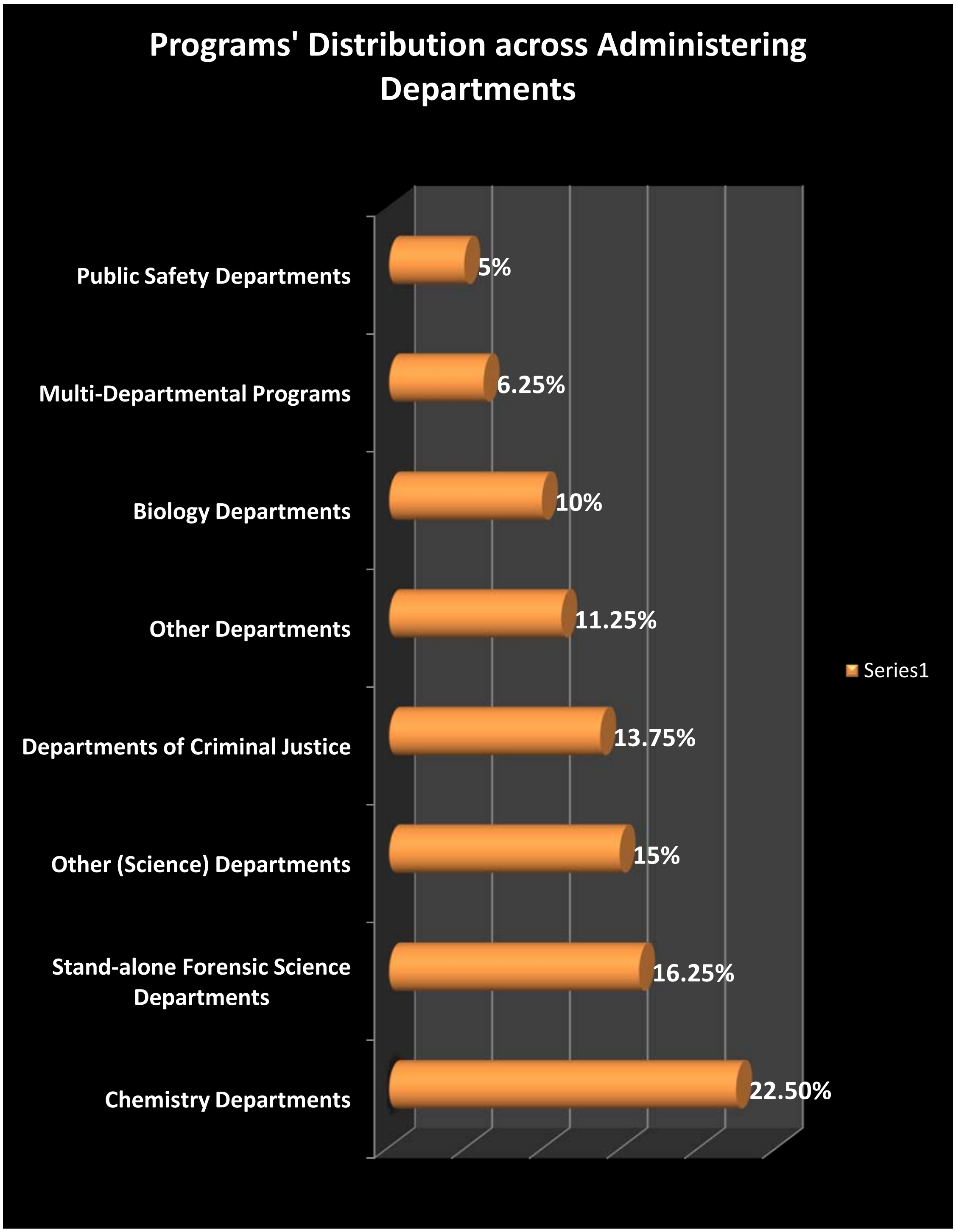
COMMENTS: This is a “well-packaged program” which offers forensic science education at both the undergraduate and postgraduate levels. At the undergraduate level, the program offers forensic degrees with various specialisations: forensic chemistry, forensic biology, and environmental forensic science. Each of these specialisations is administered under the relevant department which shapes the course’s identity. At the postgraduate level, the research topic is about forensic science, but research methodology uses the discipline of one of the major sciences (chemistry, biology, physics, or maths) to investigate the research topic. The Master’s or PhD degree will then be awarded in the science discipline which was adopted to investigate the research topic and answer the research question(s). This program emphasises that a science degree is a prerequisite for any practice within the forensic science laboratories.

Appendix K

Report-A-

Distribution of Forensic Science Across Various Administering Departments

78 Forensic Science Programs across Australia, UK, USA, and Canada are considered



Report-B-

Level of Offer by Various Educational Providers

78 Forensic Science Programs across Australia, U.K., U.S.A., and Canada are considered