A Comparison Study of NAEP-TEL and ICILS

U.S. DEPARTMENT OF EDUCATION

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Table of Contents

List of Figures and Tables

Executive Summary

In response to the increasing importance of technology in education, in 2008 the National Assessment Governing Board (NAGB) initiated the development of the National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy (TEL) framework to assess the technology knowledge and skills of 4th-, 8th-, and 12th-grade students in the United States (National Assessment Governing Board 2018, p. 12). Following the development of the framework, the National Center for Education Statistics (NCES), within the U.S. Department of Education, developed the TEL assessment. The assessment was designed to "capture those aspects of the nature, processes, uses, and effects of technology that are particularly important to participation in the economic, civic, and social spheres of modern society" (National Assessment Governing Board 2018, p. xvi). In 2014, NCES administered the assessment to approximately 21,500 8th-grade U.S. students.

Because the effects of technology on education are global and have been building for decades, the International Association for the Evaluation of Educational Achievement (IEA) has conducted studies on information and communication technologies in education since 1989[1] and began developing the International Computer and Information Literacy Study (ICILS) framework in 2010 to assess students' ability to use computer technology. ICILS reports on the computer competency and information literacy skills that students need to participate in the digital world. This inaugural administration in 2013 assessed 60,000 8th-grade students across 21 countries (the United States did not participate).

In 2018, TEL and ICILS were administered to two separate samples of 8th-grade U.S. students of approximately 15,400 and 9,000 students each, respectively. To help understand the TEL and ICILS results, NCES conducted a comparison study to answer two research questions:

- *How similar (or different) are the assessment framework targets of TEL and ICILS?*
- *How similar (or different) are the characteristics of the TEL and ICILS assessment items?*

[1] IEA conducted the Computers in Education Study (COMPED) in 1989 and again in 1992. The Second Information Technology in Education Study (SITES) was conducted in 1998–99, 2001, and 2006. These studies aimed to measure the application of computer technology in education by schools and teachers.

The results of the comparison study showed that the framework targets and design features underlying the scenario-based tasks (SBTs) used in both assessments have many similarities. Both assessments have a focus on information and communication technologies, and both are digital-based assessments that use interactive features in item design. However, there are differences between the two assessments in framework scope and item characteristics. About half of the TEL framework targets are beyond the scope of ICILS; TEL evaluates students' knowledge and skills in analyzing general systems, while ICILS limits its evaluation to computer systems. ICILS uses some response modes (e.g., flowcharts) that are not used in TEL. Forty-two percent of the ICILS items do not allow students to go back to the previous item to change their answers, compared with 85 percent of the TEL SBT items. About two-thirds of ICILS items assess procedural knowledge, while only about one-third of TEL SBT items do that.

These similarities and differences need to be considered if students' performance in the two assessments is to be compared. The limitations pertaining to using the study findings to explain performance similarities or differences are also discussed at the end of the study.

Introduction

In 2018, the National Center for Education Statistics (NCES) administered two assessments—the National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy (TEL) assessment and the International Computer and Information Literacy Study (ICILS)—to two separate nationally representative samples of 8th-grade students in the United States. TEL was administered in January–March to 15,400 students, while ICILS was administered in March–May to 9,000 students. Because of some similarities in content and item formats, NCES commissioned a study to explore the similarities and differences between the two assessment frameworks as well as the characteristics of the assessment items.

About TEL

The TEL assessment was administered first in 2014 and then again in 2018 to 8th-grade students in both public and private schools in the United States. The samples of schools and students were chosen to produce representative data for schools and students across the nation.[2]

In the TEL framework, technology is defined as "any modification of the natural world done to fulfill human needs or desires," and engineering is defined as "a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants" (National Assessment Governing Board 2018, p. xvi). The framework defines technological and engineering literacy as "the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals" (p. 5). The TEL framework measures three content areas: Technology and Society, Design and Systems, and Information and Communication Technology.

Technology and Society refers to how technology affects society and the natural world[3] and the ethical questions stemming from those effects. ***Design and Systems*** includes "the nature of technology, the engineering design process by which technologies are developed, and basic principles of dealing with everyday technologies, including maintenance and troubleshooting" (National Assessment Governing Board 2018, p. xvii). ***Information and Communication Technology*** covers "computers and software learning tools, networking systems and protocols, hand-held digital devices, and other technologies for accessing, creating, and communicating information and for facilitating creative expression" (p. xvii). These content areas cut across three practices[4]: Understanding Technological Principles, Developing Solutions and Achieving Goals, and Communicating and Collaborating. Students are presented with problems from TEL content areas that require them to apply TEL practices.

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[2] For more information about NAEP TEL, visit https://nces.ed.gov/nationsreportcard/tel/

[3] The TEL framework defines the "natural world" as "plants, animals, water, and other organisms and elements that exist without contributions from humans" (National Assessment Governing Board 2018, p. 129).

[4] "Practices" as used in the TEL framework refer to particular ways of thinking and reasoning that students are expected to be able to apply to solve problems (National Assessment Governing Board 2018, p. xviii).

Using scenario-based tasks (SBTs) in addition to traditional discrete items, TEL aims to measure students' ability to apply technology and engineering skills to real-life situations. The SBTs employ real-world scenarios to engage students in technology and engineering problems spanning multiple, interdependent items. The information from interdependent items is enriched by the addition of discrete, standalone items.

Students taking the TEL assessment use NCES-provided laptop computers and are asked to complete two 30-minute blocks. Each block is composed of either one SBT or a combination of a short SBT and discrete items. The assessment also surveys students about their experiences with technology (both in and outside of school) and school administrators about technology resources and practices.

About ICILS

ICILS, first administered in 2013 with 21 countries or education systems and again in 2018 with 14 countries or education systems including the United States, is an international, computer-based assessment of 8th-grade students sponsored by the International Association for the Evaluation of Educational Achievement (IEA). ICILS defines its international target populations based on the number of years of formal schooling that students have received. Specifically, ICILS includes students who are in their 8th year of education. In many countries, students reach their 8th year of schooling when they are 13.5 years old or above. ICILS also administers questionnaires to 8th-grade teachers (randomly sampled), principals, and the ICT coordinators of sampled schools.[5]

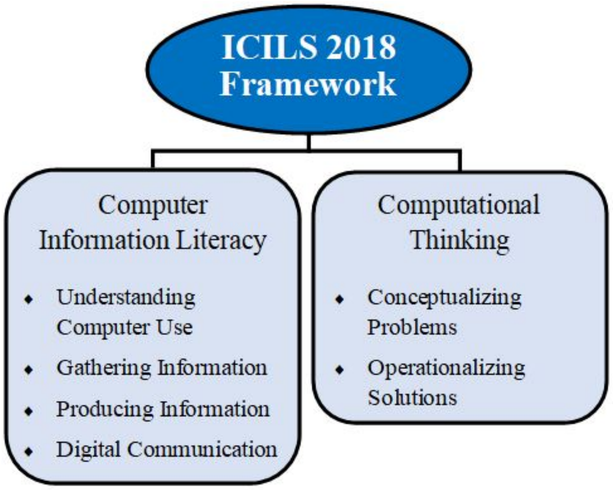
ICILS 2013 explored international differences in students' Computer and Information Literacy (CIL), and ICILS 2018 was expanded to assess students' Computational Thinking (CT) as an optional component. The United States administered both the CIL and CT components to students in 2018.[6]

The ICILS 2018 Assessment Framework (figure 1) defines Computer and Information Literacy (CIL) as "an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society" (Fraillon et al. 2019, p. 1). The framework defines Computational Thinking (CT) as "an individual's ability to recognize aspects of real-world problems which are appropriate for computational formulation and to evaluate and develop algorithmic solutions to those problems so that the solutions could be operationalized with a computer" (p. 1). The measurement of CT was offered as an option in the 2018 ICILS administration.

[5] For more information about ICILS, visit https://nces.ed.gov/surveys/icils/.

[6] Unlike TEL, ICILS does not have a single scale—CIL and CT are measured and reported separately.

Figure 1. International Computer and Information Literacy Study (ICILS) 2018 Framework



SOURCE: International Association for the Evaluation of Educational Achievement (IEA), International Computer and Information Literacy Study (ICILS), 2018.

The ICILS cognitive assessment consists of testing "modules." Like TEL blocks, students are given 30 minutes to complete each ICILS module. Students taking the ICILS assessment have 120 minutes to complete four modules. Each module contains multiple items contextualized in a single scenario and resembles a scenario-based task in TEL. The items at the beginning of a module, each called "a short task" in ICILS, are less complex than the items that follow and typically take about a minute to finish. The last item in a module, called "a large task," is usually more complex and takes more time to complete. For example, students may be asked to create a poster or presentation.

ICILS surveys students, teachers, school administrators and ICT coordinators to understand the use of technology in teaching and learning, both in and out of school. ICILS also includes a national context questionnaire—posed to national ICILS research coordinators, who draw upon national experts to answer the questions—which collects data on educational policies and guidelines related to the use of technology in schools.

Comparing TEL and ICILS

Administered in the spring of 2018 to 8th-grade U.S. students, both assessments were presented on computer equipment provided by NCES. The results of TEL 2018 were released in April 2019 and the results of ICILS were released in November 2019. Table 1 below provides a summary of the key elements of the two assessments administered in 2018.

Table 1. Similarities and differences between key elements of TEL and ICILS

Assessment aspects	TEL	ICILS
Assessment focus	Technology and engineering literacy	Computer and Information Literacy; and Computational Thinking
Assessment sponsor	U.S. Department of Education	International Association for the Evaluation of Educational Achievement
U.S. assessment administrator	National Center for Education Statistics	National Center for Education Statistics
Assessment scope	Domestic	International
Assessment time	60 mins for cognitive items	120 mins for cognitive items
Survey questionnaire	Student (15 mins) School (25 mins)	Student (30 mins) School (20 mins) Teacher (30mins)
Population	8th-grade students	8th-grade students
U.S. sample size	Schools (600) Students (15,400)	Schools (300) Students (9,000) Teachers (4,500)
Sample drawn	January–February 2017	May 2017
Administration window	January–March 2018	March–May 2018
Assessment equipment	NCES-supplied laptops	NCES-supplied tablets
Accommodations for students in assessment delivery platform	Available	Not available
Reporting window	April 2019	November 2019

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP) Technology and Engineering (TEL) Assessment, 2018; and International Association for the Evaluation of Educational Achievement (IEA), International Computer and Information Literacy Study (ICILS), 2018.

Purpose of the study

Given the similarities between the 2018 TEL and ICILS, two pressing research questions were raised:

- *How similar (or different) are the assessment framework targets of TEL and ICILS?*
- *How similar (or different) are the characteristics of the TEL and ICILS assessment items?*

Answering these questions will enable NCES and U.S. stakeholders to better understand the nature and comparability of the 2018 TEL and ICILS assessments. This information is necessary for NCES to address questions raised by policymakers and educators, produce special reports for certain stakeholders, and improve the quality and resource efficiency of the two assessments in future cycles.

Benefits of the framework comparison

Comparing the TEL and ICILS frameworks has two main benefits. First, similarities between the frameworks suggest areas where TEL data can provide assessment measures and achievement data on students' grasp of the technology and engineering principles described in the ICILS framework, and vice versa. Second, differences between the two frameworks suggest areas where the TEL and ICILS assessments can provide unique measures of students' knowledge and abilities. Identifying the comparable and incomparable framework targets enables a more nuanced analysis of students' performance on the TEL and ICILS assessments.

Beyond the differences in framework scope, the two assessments also employ different design principles for items and test delivery systems. Therefore, the American Institutes for Research (AIR) also conducted an analysis of the two assessments' item pools in this study in addition to the framework target comparison.

Benefits of the item format comparison

Whereas the TEL and ICILS frameworks represent the *intentions* of each respective assessment, the items embody the *implementation* of each framework. Differences in item formats can affect the actual participating student sample or have effects on student performance. For example, TEL items are presented on a digital platform that offers accessibility tools such as magnification, text-to-speech read-aloud, and high-contrast presentation mode.[7] ICILS does not have these tools, so participating students who need accommodations can be excluded from the assessment per participating schools' discretion.

[7] For more information about student accommodations and inclusion, visit https://www.nationsreportcard.gov/tel/about/samples-inclusion-participation/.

Study Methodology

This study consists of two parts: an assessment framework comparison of TEL and ICILS, and an analysis of the item design features of the two assessments. Both parts of the study were concurrently analyzed in three stages.

In Stage 1, TEL and ICILS framework targets were matched based on the scope of the concepts or topics measured in the targets, and assessment items were coded based upon their features. Multiple team members individually matched the framework targets and coded the item characteristics, and then convened to adjudicate any differences.

In Stage 2, the team convened a panel meeting of experts—familiar with technology literacy, interactive computer technology, national and international assessments, and the cognitive fields underlying these assessments—from October 18 to 22, 2017, to provide input on the comparison between TEL and ICILS. A panel meeting occurred with four researchers familiar with TEL, ICILS, or similar technology literacy frameworks.[8]

The panel members were asked to provide input on (1) the alignment of the two frameworks upon which the assessments are built, regrouping the targets when needed and providing their individual rating of the groupings, (2) methods to capture the characteristics of the items employed by the two assessments, and (3) plans for reporting and sharing the comparison study results as context for the assessment results.[9]

In Stage 3, the AIR research team averaged experts' individual ratings of the assessment target groups. The item characteristic codes were updated based upon the coding categories modified by the panel.

Aligning the TEL and ICILS frameworks

In Stage 1, the TEL framework targets were matched to ICILS framework targets. Comparatively, most of the ICILS framework targets cover broader areas than most of the TEL framework targets, allowing one or more TEL framework targets to fit under a single ICILS target.

In Stage 2, the expert panel evaluated these preliminary groupings on a 5-point scale, ranging from 0 to 4.[10] Table 2 shows how each score was defined.

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[8] One panel member dropped out a day before the panel meeting due to illness, so the final panel contained four members.
[9] Participating panelists' biographical statements can be found in appendix A. The agenda for the meeting can be found in appendix B.
[10] For more information about the methodology, visit https://nces.ed.gov/nationsreportcard/subject/science/pdf/ngss_naep_highlights_report.pdf.

Table 2. Framework groupings: Ratings and definitions

Rating	Definition
4	Overlapping with same focus
3	Overlapping with somewhat similar focus
2	Overlapping, but slightly different focus
1	Overlapping, but very different focus
0	No overlap

The panelists first individually rated the proposed framework groupings and then discussed the compiled ratings and disagreements. In the initial discussion, panel members sometimes suggested alternate groupings from those proposed, sometimes agreeing to add or remove framework targets. Finally, the panelists provided a second rating for each proposed grouping and provided their rationale before advancing to the next framework grouping.

The panelists were asked to consider the following questions when assigning similarity ratings for each framework grouping:

- What is the primary focus/emphasis of the concepts measured in this group?
- What is the breadth of content covered?
- What is the depth of content covered?
- How advanced is the content?
- Are specific portions of the possible content in one framework included/excluded in the other?
- What types of items/tasks could be developed to assess the content in the group?

Analysis of item characteristics

The analysis of item characteristics began with a review of the TEL and ICILS item pools. The resulting TEL-ICILS Item Classification Guide (see appendix C) yielded 11 categories:

1. **Framework Coverage:** How each assessment organizes the competencies (content area and/or practices) covered by each item
2. **Context:** The scenario/topic being used to engage respondents. The *specific* contexts are varied, so for TEL-ICILS comparison purposes, contexts are categorized into 1 of 10 possible buckets.
3. **Related Subject:** An 8th-grade subject that informs/teaches the content and/or competencies being assessed.
4. **Design Elements:** Media elements used in the item and stimulus information.
5. **Item Response Mode:** The method(s) that respondents must use to provide responses. Additional notes are added to the subcategory column when necessary.
6. **Scrolling:** Any scrolling used in an item.

7. **Navigation Linearity:** The freedom of movement the respondent has within the task (for scenario-based tasks only).[11]
8. **Interactive Features:** A classification of whether the item and stimulus information contain interactive features (e.g., a model that respondents can use to run trials in order to answer items, or elements that students can add or remove).
9. **Scoring Level:** The number of scoring levels contained in the item's scoring rubric.
10. **Scoring Method:** A classification of items measured by whether they are scored by humans or machines.
11. **Item Knowledge Type:** The type of knowledge presented in the item (including the stimulus or stem of the item).

These categories do not contain assessment-level features.[12] For example, TEL implements systemwide universal-design accommodations, such as text-to-speech, background color contrasts, and zoom capability in the assessment delivery platform, while ICILS does not contain any comparable tools.

Using the 11 item-level characteristics contained in the preliminary TEL-ICILS Item Classification Guide, all TEL and ICILS items were coded and summary statistics were produced for each assessment. The expert panel reviewed the preliminary item classification guide and summary statistics and recommended minor changes affecting four existing coding categories: Framework Coverage, Related Subject, Item Response Mode, and Design Elements. The changes were as follows:

- For the *Framework Coverage* category, the panelists suggested coding all ICILS items onto TEL practices to provide one more dimension for comparison.
- For the *Related Subject* category, the panelists' only question was the difference between Health and Science curricula for 8th-graders and whether "health" might be a better fit for some of the biology-related items currently coded as "science."
- For the *Item Response Mode* category, the panelists had concerns that "artistic" might be more accurately titled "design elements," and they suggested relabeling it as "creative." Also, as there is only one instance of a drop-down menu item, the panelists advised that it would be better placed under the multiple-choice single-selection category, since students are still selecting from provided options.
- Panelists' comments regarding *Design Elements* included changing "none" to "text only" and renaming the category "Item Presentation Elements" (originally named "Item Presentation Media" and ultimately named "Design Elements"). The panel also recommended breaking up the entry for simulated computer applications and changing the entry title to "User Interface Navigation."

[11] When students interact with TEL discrete items, they can answer the items in any order they wish because there is no scenario requiring a beginning, middle, or end. This feature of TEL discrete items is assessment wide and as such is not calculated at an item level.

[12] Although these assessment-spanning differences did not need to be coded item by item, it is important to note that they almost certainly affect construct measurement and could lead to differences in student performance. Thus, assessment-spanning differences should be taken into consideration when comparing the results of the two assessments.

The panel did not advise adding or removing a new category. In Stage 3, the panels' input was incorporated into an updated TEL-ICILS Item Classification Guide. The final coding of the TEL and ICILS items to each category shows the panel's input.

Results

The results of the framework and item format comparisons show that although there is some overlap between the targets in the TEL and ICILS frameworks, about half of the TEL framework targets are beyond the scope of ICILS targets. Analysis of the item pools shows that the two digital-based assessments use many innovative features in item design, as both include similar response modes, media elements, and interactive features. However, the different item features could lead to very different student experiences. The two assessments may favor different students based on their previous skills or knowledge. The findings from the comparison of the two frameworks and their assessment items are discussed next.

Framework similarities and differences

Among 47 targets in the TEL framework and 12 targets in the ICILS framework, 26 TEL targets are grouped with ICILS targets because of overlapping content, forming a total of 12 groupings. The average rating of panel members is 3 or 4 for 10 out of the 12 groupings, indicating similar content and focus. Of the remaining groupings, 2 were given a rating of 1. Lastly, the remaining 21 TEL targets are not grouped with any ICILS targets because of a lack of clear overlap. In general, the panel observed that TEL's focus on "technology" is broader than ICILS's focus on "computers." Despite this broader focus, the average TEL individual framework target focuses on a more specific aspect of knowledge or skills than an individual ICILS target. As a result, the panelists often remarked that the clusters of TEL framework targets align better with ICILS targets than do the individual components of those clusters.

Based on the experts' ratings and comments, the grouping and alignment of the TEL and ICILS assessment targets were updated. Table 3 shows a summary of the finalized TEL and ICILS framework target groupings and ratings (an expanded table of the TEL and ICILS groupings can be found in appendix D).

Table 3. Framework groupings and expert panel ratings

Grouping #	ICILS target	TEL target	Rating[1]
1	CT1.1[2]	D.8.11,[3] D.8.12, D.8.15, I.8.9,[4] D.8.13	3
2	CT1.2	D.8.8, D.8.9, D.8.17	1
3	CT1.3	D.8.9, I.8.5, I.8.8, I.8.13	4
4	CT2.1	D.8.6, D.8.7, D.8.8, D.8.14	4
5	CT2.2	D.8.8	1
6	CIL1.1[5]	I.8.13	3
7	CIL2.1	I.8.4, I.8.6	3
8	CIL2.2	I.8.5, I.8.13, T.8.8[6]	3
9	CIL3.1	I.8.3, I.8.13, T.8.11	4
10	CIL3.2	I.8.3, I.8.13, T.8.11	3
11	CIL4.1	I.8.3, I.8.12, I.8.13, T.8.10	4
12	CIL4.2	T.8.12, T.8.14, T.8.15, I.8.10, I.8.11	3

[1] Ratings range from 0 to 4.
[2] Based on the ICILS framework naming convention, CT1.1 refers to the 1st aspect in the 1st strand of the Computational Thinking (CT) framework.
[3] Based on the TEL framework naming convention, D.8.11 refers to the 11th assessment target for 8th grade in the Design and System area.
[4] I.8.9 refers to the 9th assessment target for 8th grade in the Information Communication Technology area.
[5] CIL1.1 refers to the 1st aspect in the 1st strand of the CIL framework.
[6] T.8.8 refers to the 8th assessment target for 8th grade in the Technology and Society area.

The highest rated groupings feature overlapping content and focus, while also making similar cognitive demands of students. For example, CIL3.1, which targets transformation of information to make it audience-friendly/ready for consumption, was rated as having substantial overlap with the TEL clusters of I.8.3, I.8.13, and T.8.11, which ask students to manipulate information for communication purposes. The panel determined that all these targets were making similar demands (manipulation/transforming data) and for the same purpose (effective communication).

The groupings that received ratings of “3” contain framework targets with some overlapping content and some overlap in the aptitude required of students. As an example, the CIL3.2 and I.8.3, I.8.13, and T.8.11 grouping was rated a “3” because the targets make similar demands on students to manipulate data for communication, but the ICILS target focuses on data specifically in the computer context whereas the TEL targets do not expressly address computer use.

Groupings that have some overlap but received lower ratings often have some content similarity, but the specific focus and/or student requirements differ. For example, CT1.2 deals with formulating and analyzing problems, whereas D.8.8, D.8.9, and D.8.17 address specific aspects of problem solving, such as constructing models and troubleshooting processes. The panel determined that the topic was similar, but the focus and demands differed. Some of the ICILS problem-solving processes did not align with TEL; while the TEL processes could be construed as subcomponents of the ICILS statement, they were not specified in the ICILS statement. TEL D.8.8 and ICILS CT2.2 also received an average rating of only 1 because the ICILS target focuses specifically on computer coding while the TEL target is about general design process.

Many of the TEL framework targets rated as having zero comparability with any ICILS framework targets and thus were not in any groups (see table 4). Most of the Technology and Society targets from TEL were deemed to have no overlap with ICILS, which does not have a focus on impact/sustainability. TEL also has collaboration, feedback, and citation targets, which fall outside of the scope of ICILS. Panelists found some TEL targets to be very specific (e.g., redesigning tools in D.8.5), making them hard to put into any TEL cluster that more broadly aligns with ICILS.

Table 4. Ungrouped TEL framework targets

TEL content area	Framework target
Design and Systems	D.8.1, D.8.2, D.8.3, D.8.4, D.8.5, D.8.10, D.8.16, D.8.18, D.8.19
Information and Communication Technology	I.8.1, I.8.2, I.8.7
Technology and Society	T.8.1, T.8.2, T.8.3, T.8.4, T.8.5, T.8.6, T.8.7, T.8.9, T.8.13

Item characteristics: Similarities and differences

The 2018 TEL has a total of 184 items—107 across the SBTs and 77 as discrete items. Unlike the scenario-based items, discrete items bear close resemblance to traditional stand-alone items found in paper-based assessments. Given this difference, information about discrete items is presented separately from information about SBT items. The 2018 ICILS has a total of 113 items across all modules (i.e., SBTs). Tables 5 and 6 show the item distributions of the two assessments.

Table 5. TEL items, by content area

TEL content area	SBT	Discrete
Design and Systems	23	23
Information and Communication Technology	44	32
Technology and Society	40	22
Total	**107 items**	**77 items**

Table 6. ICILS items, by component

ICILS component	SBT
Computational Thinking	18
Computer and Information Literacy	95
Total	**113 items**

In addition, both TEL and ICILS items were coded in terms of the subjects to which they are related, TEL practices, item context, item response mode, scoring level, scoring method, item design elements, scrolling, navigation linearity, interactive features, and item knowledge type. Each of these characteristics is examined below.

"Related subject" refers to an 8th-grade subject that informs/teaches the content and/or competencies being assessed in an item. The results showed that about half of the ICILS items tap into computer science or technology classes, while 41 percent of TEL SBT items tap into science and 34 percent into social studies (table 7).

Table 7. Percentage of TEL and ICILS items, by related subject

Related subject	ICILS	TEL SBT	TEL Discrete
Math	2%	2%	1%
ELA	12%	2%	11%
Science	22%	41%	43%
Social Studies	16%	34%	43%
Computer Science	49%	16%	3%
Art	0%	7%	0%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

In addition to content area targets, assessments of practices[13] are required in the TEL framework but are not part of the ICILS framework. To make comparisons, ICILS items were also coded into TEL practices. As shown in table 8, about half of the ICILS items assess the practice of developing solutions and achieving goals (DSAG), while about two-thirds of TEL SBT items assess this practice. The distribution of practices assessed across the ICILS items is similar to the distribution of practices assessed across TEL discrete items.

Table 8. Percentage of TEL and ICILS items, by TEL practice

TEL practice	ICILS	TEL SBT	TEL Discrete
Communicating and Collaborating	27%	17%	27%
Developing Solutions and Achieving Goals	47%	66%	48%
Understanding Technological Principles	27%	17%	25%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

All items from both assessments were also coded for context (i.e., the story or topic used to engage students) (see table 9). In the development of the TEL items, the proposed context was reviewed to ensure that it would not be unfamiliar to any student groups. In ICILS, the proposed context was reviewed by participating countries for appropriateness. The coding results show that about half of the ICILS items are presented in the context of recreation and afterschool activities, followed by environment and sustainability and health and biosciences. TEL items cover a larger variety of contexts. In addition to the contexts employed by ICILS, TEL presents items in the context of government, industries, engineering, business, and school.

[13] TEL Practices is a TEL framework term that refers to specific approaches to thinking and reasoning to solve problems.

Table 9. Percentage of TEL and ICILS items, by context

Context	ICILS	TEL SBT	TEL Discrete
Government	0%	10%	9%
Recreation and afterschool activities	50%	21%	13%
Industries	0%	0%	3%
Agriculture	8%	11%	1%
Environment and sustainability	20%	6%	13%
Health and biological sciences	14%	0%	9%
Engineering	0%	21%	17%
Business	0%	16%	17%
Transportation	8%	0%	8%
School	0%	15%	10%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

Response mode refers to the format in which the assessment requires students to provide responses, such as the selection of answers from a set of options, drag-and-drop answers, and select-and-explain. Across the two assessments, the constructed-response format is used frequently: 29 percent in ICILS, 29 percent in TEL discrete, and 21 percent in TEL SBT (see table 10). In addition, 26 percent of ICILS items use creative work or presentation, while 27 percent of TEL SBT use the select-and-explain response format. These response modes give students great flexibility to provide rationales for their answers, which reflects the nature of technology use—in most cases, multiple solutions are possible. TEL discrete items employ more traditional response modes to assess what students know; as such, it is not surprising to see that 39 percent of the items are single-selection multiple-choice questions.

Table 10. Percentage of TEL and ICILS items, by item response mode

Item response mode	ICILS	TEL SBT	TEL Discrete
Single-selection multiple-choice	10%	18%	39%
Multiple-selection multiple-choice	0%	9%	6%
Drag-and-drop	12%	10%	6%
Select-and-explain	4%	27%	9%
Selection cluster	2%	8%	10%
Constructed response	29%	21%	29%
Action	13%	0%	0%
Flowchart	2%	0%	0%
Creative work or presentation	26%	1%	0%
Other	1%	6%	0%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

Table 11 contains a summary of scoring levels used in the two assessments. Two-score level items mean students either get the answer correct or incorrect. Three scoring levels mean students can get full credit, partial credit, or zero credit. Items with more scoring levels are usually more complex than items with fewer scoring levels. For TEL discrete items, a majority (60 percent) of the items have only two scoring levels. For TEL SBT items, about half of the items have three scoring levels and only 4 percent have 5 or 6 scoring levels. In ICILS, 42 percent of the items have two or three scoring levels, respectively, and about 10 percent have eight or more scoring levels.

Table 11. Percentage of TEL and ICILS items, by scoring level

Scoring level	ICILS	TEL SBT	TEL Discrete
2	42%	36%	60%
3	42%	47%	40%
4	6%	13%	0%
5	0%	2%	0%
6	0%	2%	0%
8	3%	0%	0%
10	3%	0%	0%
12	4%	0%	0%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

Regarding scoring methods, TEL and ICILS SBT items are similar—about half of both are scored by machines and half by human scorers (table 12). A higher percentage (62 percent) of TEL discrete items were scored by machines than were TEL SBT items.

Table 12. Percentage of TEL and ICILS items, by scoring method

Scoring method	ICILS	TEL SBT	TEL Discrete
Human scored	50%	49%	38%
Machine scored	50%	51%	62%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

In terms of item design features, aside from the systemwide universal design for accommodation purposes in TEL, 47 percent of TEL SBT items involved either data tables, avatars, or audio files (table 13). In contrast, 50 percent of ICILS items included either a user interface navigation or a web page. Both assessments use simulations (4 to 6 percent of the items) that required students to solve problems by adjusting relevant variables.

Table 13. Percentage of TEL and ICILS items, by design element

Design element	ICILS SBT	TEL SBT	TEL Discrete
Pictures	22%	19%	39%
Graphs	5%	8%	6%
Data tables	0%	14%	17%
Simulations	4%	6%	6%
User interface navigation	20%	0%	0%
Web pages	30%	9%	5%
Avatar	6%	20%	0%
E-mails	1%	6%	0%
Video	9%	4%	4%
Audio	0%	13%	0%
Text only	1%	0%	0%
Other	2%	2%	24%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

As a design principle, TEL generally avoids scrolling in items to make the item presentation as user-friendly as possible. As a result, only 5 percent of TEL SBT items require scrolling to see all content, whereas 50 percent of ICILS items require scrolling (table 14). Multiple studies have shown that students perform better when they do not need to scroll to view all the pertinent item information (Pommerich 2004 and 2007; Texas Education Agency 2008).

Table 14. Percentage of TEL and ICILS items, by scrolling in item

Scrolling in item	ICILS	TEL SBT	TEL Discrete
No	50%	95%	78%
Yes	50%	5%	22%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

Table 15 shows the summary of the navigation linearity of the items in the ICILS and TEL SBTs.[14] In both assessments, correct answers need to be presented to "level" incorrect students with correct students, allowing all of them to move forward. When the leveling occurs, students are not allowed to go back to the previous item to change their answers. As the table shows, 42 percent of the ICILS items do not allow students to go back, compared with 85 percent of the items in TEL SBTs. This comparison indicates TEL provides more leveling than ICILS.

Table 15. Percentage of TEL and ICILS items, by navigation linearity

Navigation linearity	ICILS	TEL SBT
Forward only	42%	85%
Forward and backward	58%	15%
Total	**100% (113 items)**	**100% (107 items)**

NOTE: Navigation linearity is not applicable to TEL discrete items, since they are stand-alone items. Detail may not sum to totals because of rounding.

Although many different design elements are used in both assessments, not all of them are interactive (e.g., an image). The percentage of items with interactive features is summarized in table 16. About 67 percent of TEL SBT items had interactive features, compared to 50 percent of ICILS items. As expected, TEL discrete items had the lowest percentage of interactive features.

Table 16. Percentage of TEL and ICILS items, by interactive feature

Interactive feature	ICILS	TEL SBT	TEL Discrete
No	50%	33%	95%
Yes	50%	67%	5%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

[14] Navigation linearity is not applicable to TEL discrete items, since they are stand-alone items.

The knowledge involved in the items was also compared across the two assessments. Table 17 shows that two-thirds of TEL SBT items focus on declarative knowledge, asking students to state facts, while two-thirds of ICILS items focus on procedural knowledge, asking students to go through the steps or procedures needed to solve problems. See appendix C, which shows the item classification guide, for more information about declarative and procedural item classifications.

Table 17. Percentage of TEL and ICILS items, by item knowledge type

Item knowledge type	ICILS	TEL SBT	TEL Discrete
Declarative	33%	67%	82%
Procedural	67%	33%	18%
Total	**100% (113 items)**	**100% (107 items)**	**100% (77 items)**

NOTE: Detail may not sum to totals because of rounding.

To summarize, the items in the two assessments share many similar features—using item response modes that allow flexibility and multiple solutions; tapping into knowledge in science and social studies subjects; employing similar media elements; using contexts of recreation, afterschool activities, environment, and sustainability; and having a similar proportion of items scored by machines and humans. However, there are also many differences in the focus, design, and presentation of items. Compared with ICILS, TEL uses a more diverse context to present items, focuses more on interactive features in SBTs, requires more data interpretation skills, provides more leveling, and avoids scrolling in items. ICILS has more complex items, assesses more computer interface skills, and focuses more on procedural knowledge and skills than TEL does. See appendix E for a sample item classification using a TEL item, appendix F for a sample ICILS item, and appendix G for a summary table of the TEL and ICILS item characteristic categories.

Limitations of the Comparison Study

There are limitations to the findings from this framework and item characteristics comparison study. The limitations mainly pertain to using these findings to explain similarities or differences in student outcomes between the two assessments. The limitations to framework-level comparisons stem from the fact that framework measurement objectives are targets—they are the constructs that are *intended* to be assessed. However, the resulting assessments built upon the frameworks may differ in focus and scope; this difference would not be captured by framework comparison studies, which compare measurement targets, not what is actually measured. Furthermore, among the TEL and ICILS framework targets that were found to overlap, the instruments used to measure them differ. For instance, TEL and ICILS items that measure comparable framework targets may differ in context, depth of measurement (scoring level), and response mode. A TEL item may solicit a constructed response, whereas an ICILS item measuring a comparable framework target may employ a multiple-choice response format. A student may perform differently on the constructed-response item than on a multiple-choice item given the different stimulus or clues they can get from the item wording. Moreover, the constructed-response item may have a partial-scoring level whereas the multiple-choice item may only allow for correct and incorrect scores. It is possible that a student who scores "incorrect" on the multiple-choice format would be able to achieve at least a partial score on a constructed-response item.

In addition to the item-level difference between TEL and ICILS, there are assessment-level differences that could lead to variations in performance. TEL provides systemwide accommodations—such as text-to-speech, background color contrasts, and zoom capability—that are built into the assessment delivery platform. These universal-design accommodations (e.g., a digital read-aloud tool) are provided to all U.S. students who participate in NAEP digital assessments, regardless of special needs. This differs from ICILS, which does not have such accommodations built into the test delivery platform but allows extra time and intermittent reading aloud if needed. Some students with special needs who needs accommodations may have been excluded from participating in ICILS.[15] The different approach to accommodations produced a different student experience and may have resulted in a slightly different student sample.

[15] The U.S. student exclusion rate met international requirements (under 5%).

Additional, assessment-spanning differences include the computer equipment used to deliver the digital assessments. In the United States, students took the TEL assessment on laptops with a mouse attached, whereas the ICILS assessment was administered on tablets[16] paired with attachable keyboards and mice. The equipment for both tests administered in the United States was supplied by NCES, ensuring standardization in the administrations of the assessments. Conversely, there was no standardization of the equipment used in the international ICILS samples beyond minimum equipment requirements (screen size, keyboard, mouse, etc.). It is thus possible that differences in devices may have driven some of the differences in student performance. For example, students may have typed differently on the thin, chiclet-style keyboards attached to the ICILS tablets than on the large keyboards used in the TEL laptops.

Conclusions

The results of this study show that about half of the TEL framework targets fall within the scope of the ICILS framework, and the other half fall outside of it. The most similar content areas measured in the two assessments are information and communication technologies. However, there are differences. TEL does not focus on computational thinking and ICILS does. TEL evaluates students' knowledge and skills about analyzing general systems, while ICILS limits its evaluation to computer systems. TEL includes any technology and its impact on society as one of three framework content areas, whereas ICILS focuses primarily on ethical issues related to computer technology and internet use.

There is significant overlap in the item formats and characteristics employed by the two assessments. However, there are many different features and design considerations that may confound direct comparison of student performance. As such, the comparability of student performance could be enhanced with further analysis of scoring and standards-setting practices. In addition, comparisons of subpopulations of participating students would yield more comparable results (for example, a comparison of TEL students who eschewed or lightly used the available accommodation features to ICILS students who did not have those accommodations).

The findings of this study can be the basis for future efforts to incorporate assessment results into the comparison analysis to help researchers and practitioners better understand the differences and similarities of students' performances in TEL and ICILS.

[16] Although the ICILS assessment was delivered on touch-screen tablets in the United States, the touch-screen interface was disabled. As with traditional laptops, the only way students could interact with the devices was through keyboards and mice.

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Appendixes

Appendix A. List of Expert Panelists

TEL-ICILS Comparison Study:
Technical Review Panel
Expert Biographies
October 18-20, 2017 | Washington, D.C.

Esther Care

Senior Fellow, Center for Universal Education, Brookings Institution

Esther Care works to promote effective assessment practices that inform both policy and classroom practice. She has worked primarily in the Asia Pacific with a focus on providing evidence-based advice to ministries of education implementing or planning to implement major education reform. Dr. Care's work is characterized by consideration of the interactions between assessment, curriculum, and pedagogy. With the increasing focus globally on the need to promote generic skills, such as problem solving, critical thinking and collaboration, she has worked with ministries of education to identify how to incorporate these skills into the educational process.

Dr. Care is a director of the Assessment Curriculum and Technology Research Centre (funded by the Australian Government's Department of Foreign Affairs and Trade, in the Philippines), which conducts large- and small-scale research in the Philippines to inform that country's major K-12 education reform. This work emphasizes the dependencies across curriculum, assessment, and pedagogy and is designed to provide quick feedback to the government on the roll-out of the reforms.

Dr. Care has had long-term working relationships with Australian education providers in early literacy development and working with teachers to improve skills in data interpretation and use to drive student learning. Resulting from her research as chief investigator on several Australian Research Council grants, she has published in journals and books spanning vocational and educational psychology to education assessment and policy, most recently with an emphasis on the assessment of 21st century skills.

Leigh Ann DeLyser

Director of Education and Research, CSNYC

Leigh Ann DeLyser is the director of education and research at the NYC Foundation for Computer Science Education (CSNYC). In this role, Dr. DeLyser is working to expand computer science to all schools in the New York City public school system. CSNYC is the private partner in the $80 million initiative requiring every school to offer one unit of computer science to every student in public schools. She is a coauthor of the Running on Empty report, a 50-state analysis of computer science standards. Prior to obtaining her doctorate in computer science and cognitive psychology from Carnegie Mellon University, Dr. DeLyser was a high school computer science and math teacher and a two-term member of the board of directors of the Computer Science Teachers Association. She also helped start the Academies for Software Engineering in New York City as a proof of concept that all students could learn computer science.

Dr. DeLyser is a lifelong advocate of computer science education. At CSNYC, she oversees research efforts and advising and implementing programs that align with the organization's strategic goals. She is also a co-chair of the CSforAll Consortium, a national network of computer science education content providers, school districts, education associations, and researchers devoted to the mission of CSforAll. Dr. DeLyser earned her Ph.D. from Carnegie Mellon University in Computer Science and Cognitive Psychology, with a focus on computer science education**.**

Sara Dexter

Associate Professor
Department of Leadership, Foundations & Policy
Curry School of Education, University of Virginia

Sara Dexter is an associate professor of education with expertise in technology leadership. Dr. Dexter's experience in administration at the school district level brings a unique perspective to the Administration and Supervision faculty concerning the systemic implementation and integration of technology at the district, school, and classroom levels. Her first-hand experience in designing and implementing professional development on the instructional use of technology for a public school district in Minnesota is reflected in her passion for bringing awareness, understanding, cohesion, and research to the exciting nature of technology leadership.

Dr. Dexter's primary research interests lie in exploring the relationship between educational leadership, technology leadership, and resource management. She has an extensive background in the development of case-based learning environments for both aspiring teachers and school administrators. A current federally funded grant supports the development, implementation, and research of web-based, interactive cases for the development of pre-service administrators' decisionmaking skills. Her research incorporates decisionmaking skills at multiple levels of leadership regarding technology implementation.

Through her courses, she guides school leaders in strategically designing systems in which students' needs might be best served by the leadership structures used for implementation of technology in schools. An integral part of her instruction includes facilitating the process of honing school leaders' skills to discern how to tackle technology implementation through the collaborative utilization of human resources and the use of available technology within their schools. Based on her innovative research in technology leadership, she was the 2009 recipient of the **University Council for Educational Administration's Jack A. Culbertson Award**, presented annually to an outstanding junior professor of educational administration, in recognition of her contributions to the field.

Don Knezek

Senior Global Education Consultant

Don Knezek, former CEO of the International Society for Technology in Education (ISTE), is recognized internationally for his leadership in transforming learning and teaching through effective and innovative uses of technology. He has led innovation at all levels of education, from classrooms and school districts to state, national, and international projects. Recent leadership efforts include directing a national center for teacher preparation; consulting with ministries of education and affiliated groups from all over the world on digital age standards; and partnering with UNESCO on its ICT Competency Framework for Teachers and related credentialing programs for 21st century teaching. Dr. Knezek holds a bachelor's degree cum laude from Dartmouth College, a master's degree from the University of Hawaii, and a Ph.D. from the University of Texas. He is a tireless advocate for universal education.

Appendix B. Expert Panel Meeting Agenda

TEL-ICILS Comparison Study: Expert Panel

October 18-20, 2017 | Washington, DC

American Institutes for Research (AIR)
1025 Thomas Jefferson Street NW
Room 3131

Contact Number: (202) 403-6568

AGENDA

Wednesday, October 18, 2017

1:00 pm	**Registration**
1:30 pm	**Welcome and Introductions – everyone**
2:00 pm	**Introduction of TEL and ICILS – Taslima Rahman, William Ward, Lydia Malley from NCES**
3:15 pm	**Break**
3:30 pm	**Overview of the Study, Review Materials and Procedures – Yan Wang**
4:00 pm	**Practice Framework Review**
5:00 pm	**Adjourn**

Thursday, October 19, 2017

9:00 am	**Summary of Prior Day's Discussion**
9:15 am	**Comparison of ICILS and TEL Frameworks – Panel/AIR**
11:00 am	**Break**
11:15 am	**Comparison of ICILS and TEL Frameworks (cont.) – Panel/AIR**
12:30 pm	**Lunch**
1:30 pm	**Comparison of ICILS and TEL Frameworks (cont.) – Panel/AIR**
2:45 pm	**Break**
3:00 pm	**Comparison of ICILS and TEL Frameworks (cont.) – Panel/AIR**
4:30 pm	**Debrief**
5:00 pm	**Adjourn**

Friday, October 20, 2017

8:30 am	**Summary of Prior Day's Discussion**
9:00 am	**ICILS and TEL Items and Their Characteristics (preliminary results) – Yan Wang**
10:00 am	**Discussion of the Coding Categories/Scheme – Panel/AIR**
11:00 am	**Break (hotel check-out)**
11:30 am	**Discussion of the Coding Categories/Scheme (cont.) – Panel/AIR**
12:30 pm	**Lunch**
1:30 pm	**Panel Suggestions on Additional/Future Analyses – Panel**
2:30 pm	**Break**
2:45 pm	**Current Plans for Reporting Study Results – Taslima Rahman**
3:00 pm	**Panel Suggestions on Reporting and Dissemination – Panel**
4:00 pm	**Debrief**
4:30 pm	**Adjourn**

Appendix C. TEL-ICILS Item Classification Guide

A. Framework Coverage: How each assessment organizes the competencies covered by each item.
   a. Content Area/Dimension: Primary-level framework content found in TEL and ICILS
   b. Content Subarea/Strand: Secondary-level framework content found in TEL and ICILS
   c. Assessment Target/Aspect: Tertiary-level framework content found in TEL and ICILS
   d. Practice: Skills target found in TEL

B. Context: The scenario/topic being used to engage respondents. The *specific* contexts are varied, so for TEL-ICILS comparison purposes, contexts are categorized into 1 of 10 possible buckets.
   1. Government (voting, legislation, etc.)
   2. Recreation and afterschool activities (hobbies, outdoor activities, etc.)
   3. Industries (industrial fishing, computer industry, etc.)
   4. Agriculture (farming, farming science, etc.)
   5. Environment and Sustainability (alternative energy, recycling, etc.)
   6. Health and Biosciences (biology, body functions, etc.)
   7. Engineering (machine processes, systems, etc.)
   8. Business (cost or revenue related to a business)
   9. Transportation (car travel, bus system, etc.)
   10. School (class assignment, school infrastructure, etc.)

C. Related Subject: An 8th-grade subject that informs/teaches the content and/or competencies being assessed.
   1. Math
   2. English Language Arts
   3. Science
   4. Social Studies
   5. Computer Science
   6. Art

D. Item Design Elements: Media elements used in the item and stimulus information.
    1. Pictures
    2. Graphs (including flowcharts)
    3. Data tables
    4. Simulations
    5. User interface navigation (computer system and application navigation)
    6. Web pages
    7. Avatar
    8. E-mails
    9. Video
    10. Audio
    11. Text only
E. Response Mode: The method(s) that respondents must use to provide responses. The response modes are arranged as follows. Additional notes are added to the subcategory column when necessary.
    1. Single-Selection Multiple-Choice: A multiple-choice question with one answer.
    2. Multiple-Selection Multiple-Choice: Multiple-choice question with multiple correct answers possible. Must select all correct answers for full credit.
    3. Drag-and-drop: Item where answer is created by dragging responses into a grid or table.
    4. Select-and-Explain: Item where answer is a multiple-choice question followed by a constructed-response explanation.
    5. Selection Cluster: Series of binary items, scored together as one item.
    6. Constructed Response: Item where response is a typed answer only. Also, items where a hyperlink or other item must be copied/pasted.
    7. Action: an action (e.g., click on a link, select a file) is captured and scored.
    8. Flowchart: Item where response is a multi-selection from a chart or graph. Selections are individual clicks.
    9. Creative work or presentation: Items that are determined by design ability. Examples include appropriate picture placement, text/background contrast, and editing a photo.
    10. Other: Items that did not fit into any categories above (e.g., sorting, data entry, drop-down menu, drag an object).
F. Scrolling: Any scrolling used in an item gets marked as a 'yes.'
    1. Yes
    2. No
G. Navigation Linearity: (For scenario-based tasks only), the freedom of movement the respondent has within the task.
    1. Forward only: Test does not allow you to return to previously answered items.
    2. Forward & backward: Test allows for going back to prior items or advance to any or some future items.

H. Interactive Features: A classification of whether the item and stimulus information contain interactive features (e.g., a model that respondents can use to run trials in order to answer items). Note that videos, while re-playable, are not considered "interactive;" voiceover buttons for avatars are consider interactive.
    1. Yes
    2. No

I. Scoring level: The number of scoring levels the item's scoring rubric contains.
    1. Score level 2
    2. Score level 3
    3. Score level 4
    4. Score level 5
    5. Score level 6
    6. Score level 8
    7. Score level 10
    8. Score level 12

J. Scoring Method: A classification of items measured by whether they are scored by humans or machines.
    1. Human: Items that don't have fixed answers and need human grading based on scoring criteria, such as a constructed response.
    2. Machine: Items where credited answers or keys are fixed and predetermined, such as single-selection multiple-choice items.

K. Item Knowledge Type: The type of knowledge presented in item (including the stimulus or stem of the item).
    1. Declarative: The knowledge required to answer the item is factual and informational, regardless of what students are asked to do with it. Examples include opinions, data tables, background information of a debate. Students can be asked to take notes, summarize content, or make a choice.
    2. Procedural: The knowledge required to answer the item is about steps or sequence for how things progress or how to perform certain activities, regardless of what students are asked to do with it. Examples include steps to test a design, a video to show stages of a plant's growth, a flowchart that shows a food web. Students can be asked to take notes, summarize content, or make a choice.

Appendix D. Groupings of ICILS and TEL Framework Targets, Ratings, and Rationale

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CT1.1	Knowing about and understanding computer systems refers to a person's ability to identify and describe the properties of systems by observing the interaction of the components within a system.	**D.8.11** **D.8.12** **D.8.15** **I.8.9** **D.8.13**	Technological systems are designed to achieve goals. They incorporate various processes that transform inputs into outputs. They all use energy in some form. These processes may include feedback and control. Technological systems can interact with one another to perform more complicated functions and tasks than any individual system can do by itself. Construct and use a moderately complicated system, given a goal for the system and a collection of parts, including those that may or may not be useful in the system. Use a digital model of a system to conduct a simulation. Explain how changes in the model result in different outcomes. Examine a product or process through reverse engineering by taking it apart step by step to identify its systems, subsystems, and components, describing their interactions, and tracing the flow of energy through the system.	**3**	Somewhat different focus, but aptitude required is similar.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CT1.2	Formulating problems entails the decomposition of a problem into smaller manageable parts and specifying and systematizing the characteristics of the task so that a computational solution can be developed (possibly with the aid of a computer). Analyzing consists of making connections between the properties of, and solutions to, previously experienced problems and new problems to establish a conceptual framework to underpin the process of breaking down a large problem into a set of smaller, more manageable parts.	**D.8.8** **D.8.9** **D.8.17**	Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions. Construct and test a model and gather data to see if it meets the requirements of a problem. Diagnose a problem in a technological device using a logical process of troubleshooting. Develop and test various ideas for fixing it.	**1**	ICILS requires problem-solving processes not specified in TEL. Both require an understanding of problem solving, but the demands made of students are different.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CT1.3	In order to make effective judgments about problem solving within systems, it is necessary to collect and make sense of data from the system. The process of collecting and representing data effectively is underpinned by knowledge and understanding of the characteristics of the data and of the mechanisms available to collect, organize, and represent the data for analysis.	**D.8.9** **I.8.5** **I.8.8** **I.8.13**	Construct and test a model and gather data to see if it meets the requirements of a problem. Select and use appropriate digital and network tools and media resources to collect, organize, analyze, and display supporting data to answer questions and test hypotheses. Use digital tools to gather and display data in order to test hypotheses of moderate complexity in various subject areas. Draw and report conclusions consistent with observations. Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others.	**4**	The TEL statements together form the components of the ICILS target (collecting, analyzing, and displaying data).

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CT2.1	Planning solutions refers to the process of establishing the parameters of a system, including the needs of users and desired outcomes, with a view to designing and implementing the key features of a solution. Evaluating solutions refers to the ability to make critical judgments about the quality of computational artifacts (such as algorithms, code, programs, user interface designs or systems) against criteria based on a given model of standards and efficiency.	**D.8.6** **D.8.7** **D.8.8** **D.8.14**	Engineering design is a systematic, creative, and iterative process for meeting human needs and wants. It includes stating the challenge, generating ideas, choosing the best solution, making and testing models and prototypes, and redesigning. Often there are several possible solutions. Requirements for a design are made up of the criteria for success and the constraints, or limits, which may include time, money, and materials. Designing often involves making trade-offs between competing requirements and desired design features. Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions. Measure and compare the production efficiency of two machines, a simple machine and a complex machine, designed to accomplish the same goal.	**4**	This cluster of TEL statements rates higher than the individual targets because of their specificity in comparison to ICILS's relative broadness. Topic and focus are very similar.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CT2.2	This aspect focuses on the logical reasoning that underpins the development of algorithms and code to solve problems. It can involve developing or implementing an algorithm as well as automating the algorithm, typically using computer code. Creating a design in this domain refers to the intersection between users and the system. This may relate to development of the user interface elements in a program or to the design of functional specifications or requirements about how a program or system should interact with its users.	**D.8.8**	Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions.	**1**	ICILS is specifically about code and algorithms, while TEL is about design process. While there is a little overlap, the focuses are different.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL1.1	Knowing about and understanding computer use refers to a person's declarative and procedural knowledge of the generic characteristics and functions of computers. This aspect focuses on the basic technical knowledge and skills that underpin our use of computers in order to work with information.	**I.8.13**	Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others.	**3**	While the aptitude required to meet the requirements is similar in both targets, the focus is different. ICILS focuses on the data whereas TEL focuses on the tools.
CIL2.1	Accessing and evaluating information refers to the investigative processes that enable a person to find, retrieve, and make judgments about the relevance, integrity, and usefulness of computer-based information.	**I.8.4** **I.8.6**	Increases in the quantity of information available through electronic means and the ease by which knowledge can be published have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation. Search media and digital resources on a community or world issue and identify specific examples of distortion, exaggeration, or misrepresentation of information.	**3**	The TEL statements together have a very similar focus, and slightly different demand of students (ICILS emphasizes being able to do something; TEL emphasizes knowing how to do something).

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL2.2	Managing information refers to the capacity of individuals to work with computer-based information. The process includes the ability to adopt and adapt information classification and organization schemes in order to arrange and store information so that it can be used or reused efficiently.	**I.8.5** **I.8.13** **T.8.8**	Select and use appropriate digital and network tools and media resources to collect, organize, analyze, and display supporting data to answer questions and test hypotheses. Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others. Information technologies are developing rapidly so that the amount of data that can be stored and made widely accessible is growing at a faster rate each year.	**3**	Some of the TEL focus does not overlap with ICILS (e.g., the "creating" in I.8.13), but the focus and student requirements regarding data management are similar.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL3.1	Transforming information refers to a person's ability to use computers to change how information is presented so that it is clearer for specific audiences and purposes. This process typically involves using the formatting, graphics, and multimedia potential of computers to enhance the communicative effect or efficacy of information.	**I.8.3** **I.8.13** **T.8.11**	Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences. Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others. Use appropriate information and communication technologies to collaborate with others on the creation and modification of a knowledge product that can be accessed and used by other people.	**4**	The focus on maximizing information transformation is very similar. The purpose for transforming data is similar as well (effective communication) although ICILS does not have the focus on collaboration that TEL does (e.g., T.8.11).

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL3.2	Creating information refers to a person's ability to use computers to design and generate information products for specified purposes and audiences. These original products may be entirely new or may build upon a given set of information to generate new understandings.	**I.8.3** **I.8.13** **T.8.11**	Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences. Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others. Use appropriate information and communication technologies to collaborate with others on the creation and modification of a knowledge product that can be accessed and used by other people.	**3**	Significant overlap in the manipulation of data for communication. Slightly different focus between TEL's use of data tools and ICILS's broader focus on data/information in the specific context of computers.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL4.1	Sharing information refers to a person's understanding of how computers are and can be used as well as his or her ability to use computers to communicate and exchange information with others. Sharing information focuses on a person's knowledge and understanding of a range of computer-based communication platforms, such as e-mail, wikis, blogs, instant messaging, sharing media, and social networking websites.	**I.8.3** **I.8.12** **I.8.13** **T.8.10**	Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences. Certain digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other kinds of tools are appropriate for creating text, visualizations, and models and for communicating with others. Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others. The large range of personal and professional information technologies and communication devices allows for remote collaboration and rapid sharing of ideas unrestricted by geographic location.	**4**	While TEL focuses more on tools, ICILS focuses more on information. However, all of the statements in this grouping target the same domain: information sharing.

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
CIL4.2	Using information responsibly and safely refers to a person's understanding of the legal and ethical issues of computer-based communication from the perspectives of both the publisher and the consumer.	**T.8.12** **T.8.14** **T.8.15** **I.8.10** **I.8.11**	Technology by itself is neither good nor bad, but its use may affect others; therefore, decisions about products, processes, and systems must take possible consequences into account. Explain that it is important for citizens to reduce the negative impacts and increase the positive impacts of their technologies on people in another area or on future generations. Explain why it is unethical to infect or damage other people's computers with viruses or "hack" into other computer systems to gather or change information. Style guides provide detailed examples for how to give appropriate credit to others when incorporating their ideas, text, or images in one's own work. Identify or provide examples of fair use practices that apply appropriate citation of sources when using information from books or digital resources.	**3**	TEL focuses on knowing about the ethical and appropriate use of "technology," whereas ICILS focuses on appropriately using "information." Knowing is not the same as doing, and although the focus is slightly different, there is some overlap.
		D.8.1	Science is the systematic investigation of the natural world. Technology is any modification of the environment to satisfy people's needs and wants. Engineering is the process of creating or modifying technologies and is constrained by physical laws and cultural norms and economic resources.	**0**	

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
		D.8.2	Technology advances through the processes of innovation and invention. Sometimes a technology developed for one purpose is adapted to serve other purposes.	**0**	
		D.8.3	Tools have been improved over time to do more difficult tasks and to do simple tasks more efficiently, accurately, or safely. Tools further the reach of hands, voice, memory, and the five human senses.	**0**	
		D.8.4	Simulate tests of various materials to determine which would be best to use for a given application.	**0**	
		D.8.5	Redesign an existing tool to make it easier to accomplish a task	**0**	
		D.8.10	Communicate the results of a design process and articulate the reasoning behind design decisions by using verbal and visual means. Identify the benefits of a design as well as the possible unintended consequences.	**0**	
		D.8.16	Many different kinds of products must undergo regular maintenance, including lubrication and replacement of parts before they fail so as to ensure proper functioning.	**0**	
		D.8.18	Modify a moderately complicated system so that it is less likely to fail. Predict the extent to which these modifications will affect the productivity of the system.	**0**	
		D.8.19	Trace the life cycle of a repairable product from inception to disposal or recycling in order to determine the product's environmental impact.	**0**	

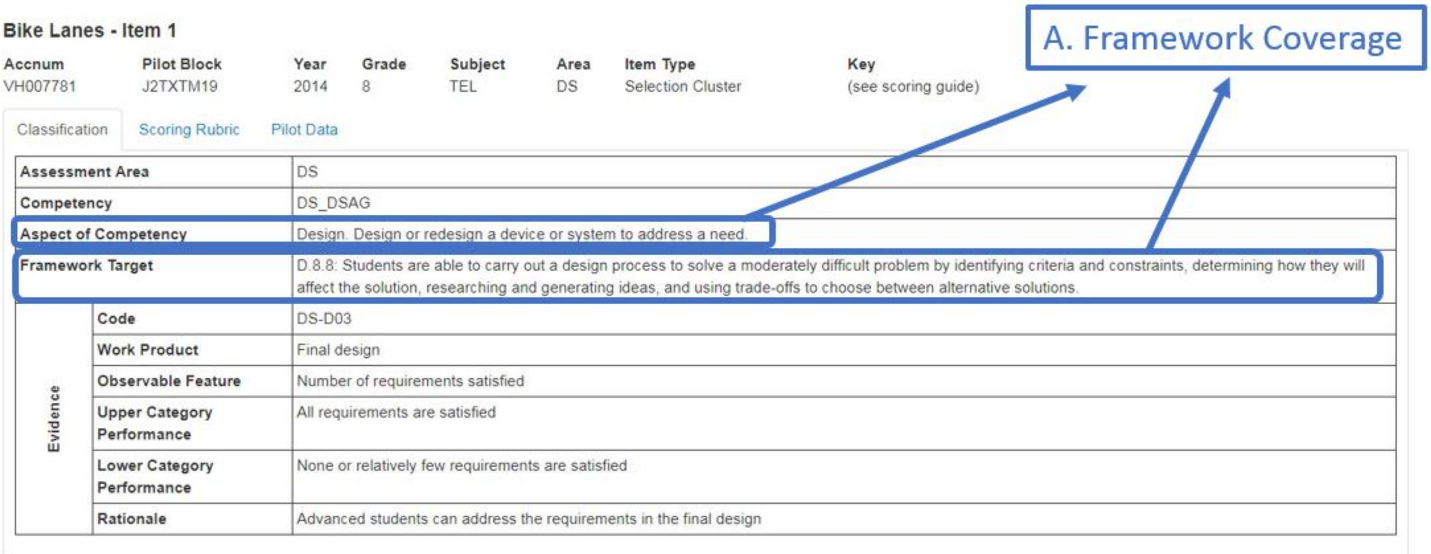
ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
		I.8.1	Collaboration can take many forms. Pairs or teams of people can work together in the same space or at a distance, at the same time or at different times, and on creative projects or on technical tasks. Different communications technologies are used to support these different forms of collaboration.	**0**	
		I.8.2	Provide feedback to a (virtual) collaborator on a product or presentation, taking into account the other person's goals and using constructive, rather than negative, criticism.	**0**	
		I.8.7	Use digital tools to identify a global issue and investigate possible solutions. Select and present the most promising sustainable solution.	**0**	
		T.8.1	Economic, political, social, and cultural aspects of society drive improvements in technological products, processes, and systems.	**0**	
		T.8.2	Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture and often leading to the creation of new needs and wants.	**0**	
		T.8.3	Describe and analyze positive and negative impacts on society from the introduction of a new or improved technology, including both expected and unanticipated effects.	**0**	
		T.8.4	Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.	**0**	

ICILS framework target #	ICILS aspect description	TEL framework target #	TEL statement description	Similarity rating	Rationale
		T.8.5	Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.	**0**	
		T.8.6	Resources such as oceans, fresh water, and air, which are essential for life and shared by everyone, are protected by regulating technologies in such areas as transportation, energy, and waste disposal.	**0**	
		T.8.7	Compare the environmental effects of two alternative technologies devised to solve the same problem or accomplish the same goal and justify which choice is best, taking into account environmental impacts as well as other relevant factors.	**0**	
		T.8.9	Information technologies make it possible to analyze and interpret data, including text, images, and sound, in ways that are not possible with human senses alone. These uses may result in positive or negative impacts.	**0**	
		T.8.13	People who live in different parts of the world have different technological choices and opportunities because of such factors as differences in economic resources, location, and cultural values.	**0**	

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP) 2018 Technology and Engineering (TEL) Assessment; and International Association for the Evaluation of Educational Achievement (IEA), 2018 International Computer and Information Literacy Study (ICILS), previously unpublished tabulations (May 2020).

Appendix E. Sample TEL Item and Item Classification

A sample released TEL item[17] is used here to illustrate item classification categories.

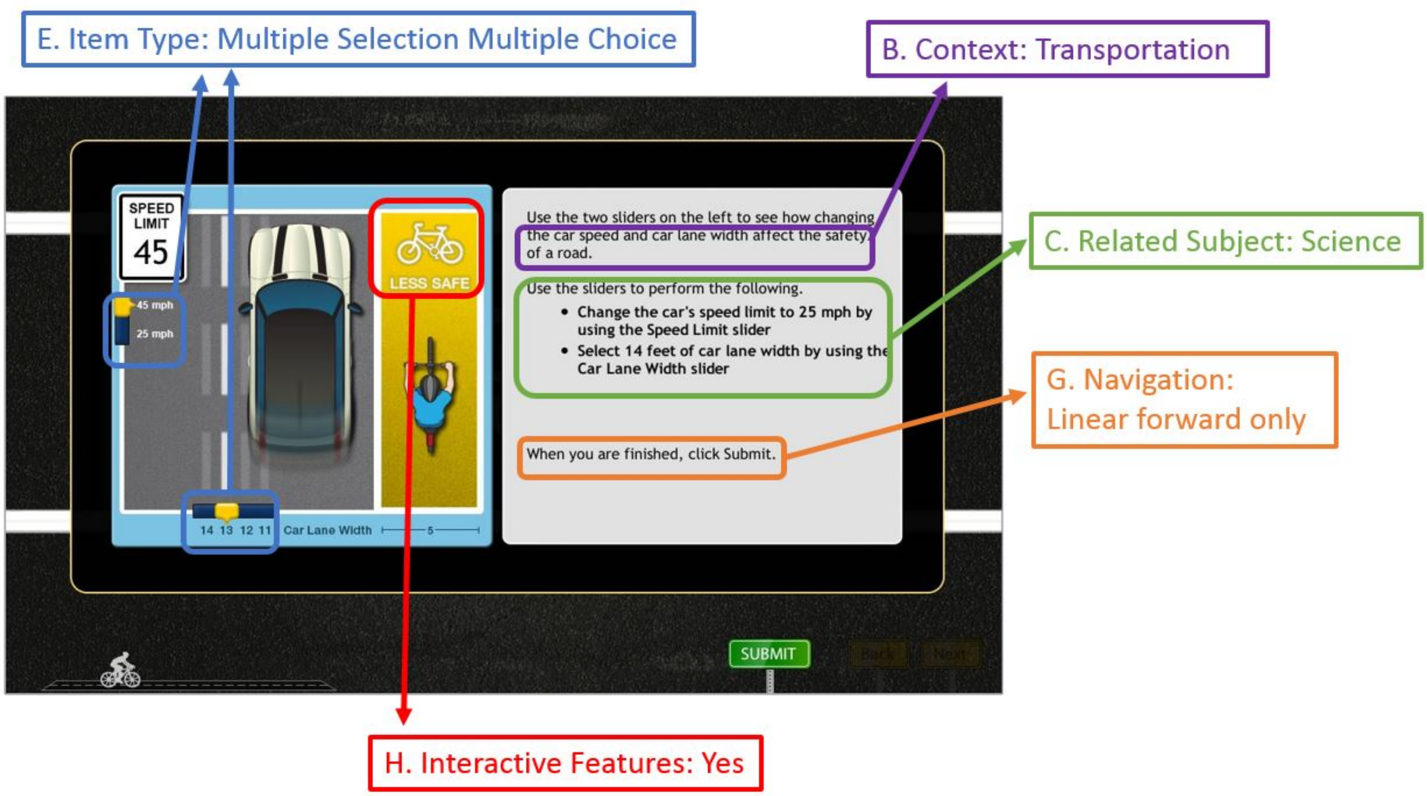


Bike Lanes - Item 1

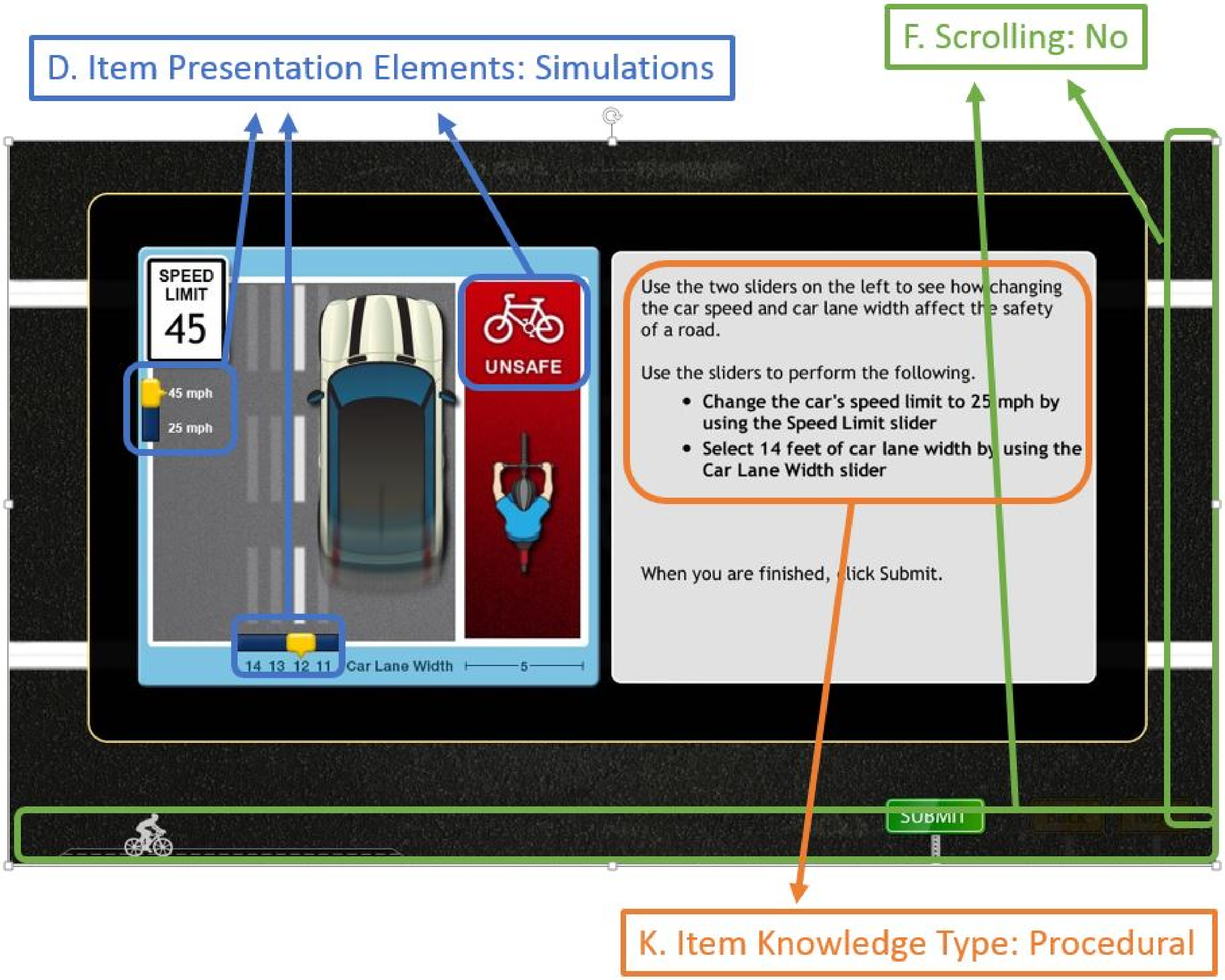
Accnum	Pilot Block	Year	Grade	Subject	Area	Item Type	Key
VH007781	J2TXTM19	2014	8	TEL	DS	Selection Cluster	(see scoring guide)

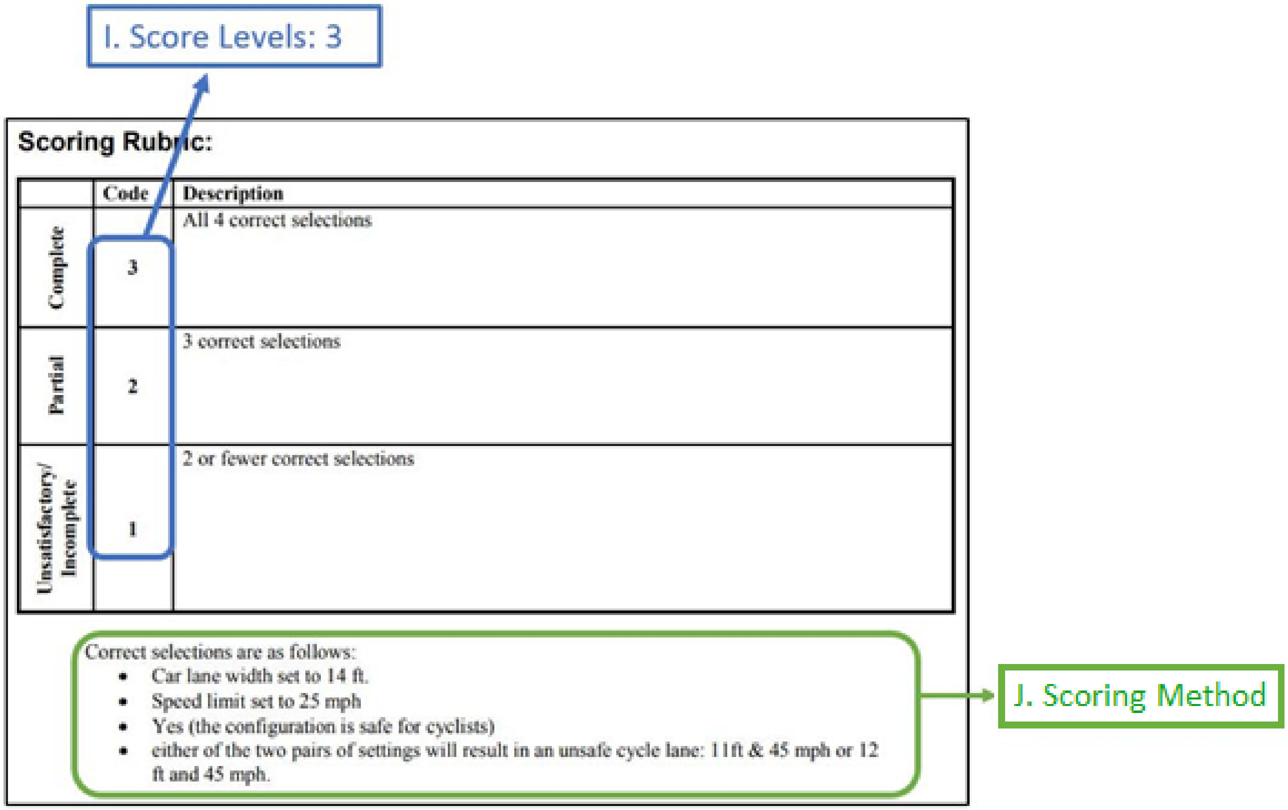
Classification | Scoring Rubric | Pilot Data

Assessment Area		DS
Competency		DS_DSAG
Aspect of Competency		Design. Design or redesign a device or system to address a need.
Framework Target		D.8.8: Students are able to carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions.
Evidence	Code	DS-D03
	Work Product	Final design
	Observable Feature	Number of requirements satisfied
	Upper Category Performance	All requirements are satisfied
	Lower Category Performance	None or relatively few requirements are satisfied
	Rationale	Advanced students can address the requirements in the final design



[17] National Assessment of Educational Progress (NAEP), 2014 Technology and Engineering Literacy (TEL) Assessment. Retrieved from https://www.nationsreportcard.gov/tel_2014/#tasks/bikelanes.


D. Item Presentation Elements: Simulations
F. Scrolling: No
SPEED LIMIT
45
45 mph
25 mph
UNSAFE
14 13 12 11
Car Lane Width
Use the two sliders on the left to see how changing the car speed and car lane width affect the safety of a road.
Use the sliders to perform the following.
Change the car's speed limit to 25 mph by using the Speed Limit slider
Select 14 feet of car lane width by using the Car Lane Width slider
When you are finished, click Submit.
SUBMIT
K. Item Knowledge Type: Procedural



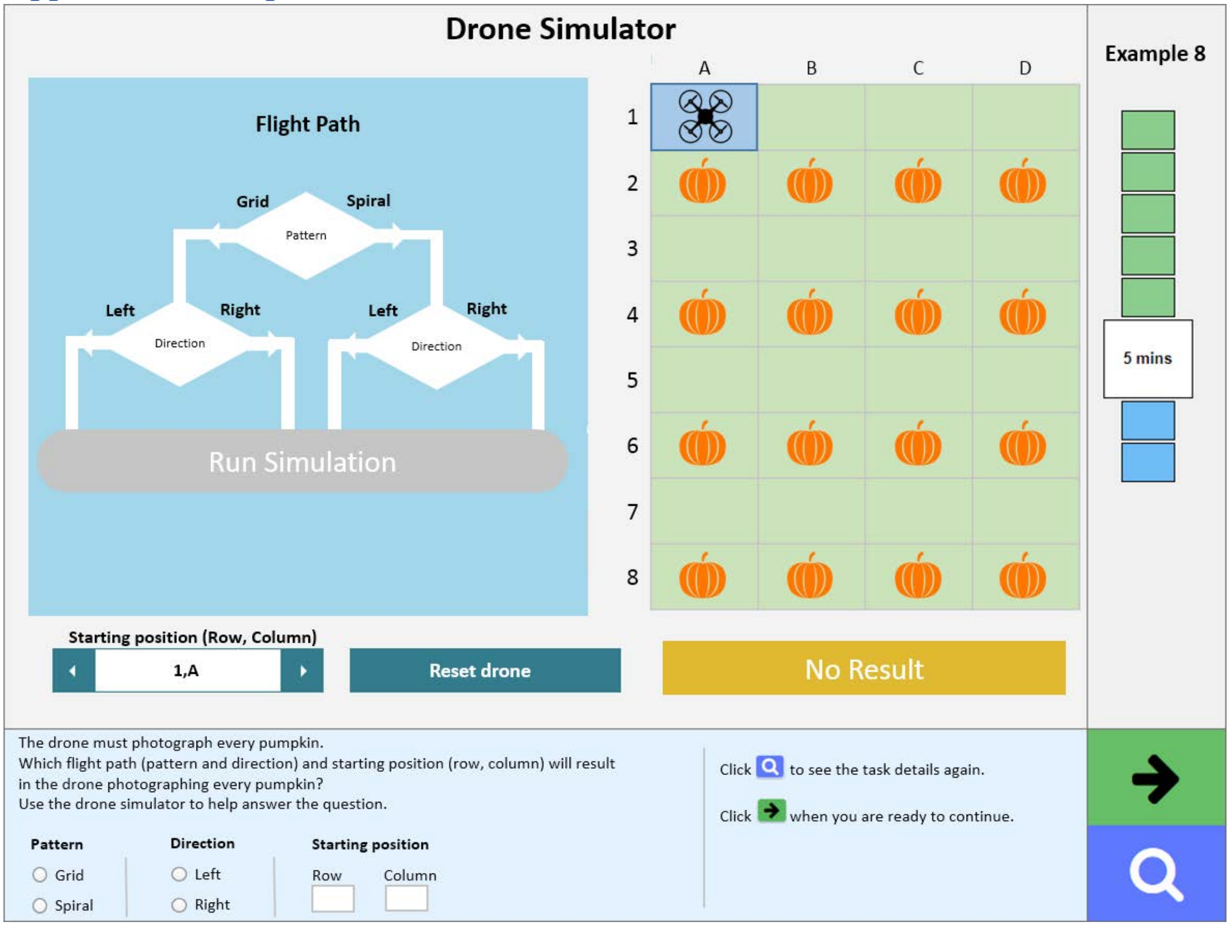
Scoring Rubric:

	Code	Description
Complete	3	All 4 correct selections
Partial	2	3 correct selections
Unsatisfactory/ Incomplete	1	2 or fewer correct selections

Correct selections are as follows:

- Car lane width set to 14 ft.
- Speed limit set to 25 mph
- Yes (the configuration is safe for cyclists)
- either of the two pairs of settings will result in an unsafe cycle lane: 11ft & 45 mph or 12 ft and 45 mph.

Appendix F. Sample ICILS Item



Appendix G. Summary Table of Item Comparisons

Table G-1. Percentage of TEL and ICILS items, by item characteristic

Item Characteristic	ICILS	TEL SBT	TEL Discrete
Related subject			
Math	2%	2%	1%
ELA	12%	2%	11%
Science	22%	41%	43%
Social Studies	16%	34%	43%
Computer Science	49%	16%	3%
Art	0%	7%	0%
TEL practice			
Communicating and Collaborating	27%	17%	27%
Developing Solutions and Achieving Goals	47%	66%	48%
Understanding Technological Principles	27%	17%	25%
Context			
Government	0%	10%	9%
Recreation and afterschool activities	50%	21%	13%
Industries	0%	0%	3%
Agriculture	8%	11%	1%
Environment and sustainability	20%	6%	13%
Health and biosciences	14%	0%	9%
Engineering	0%	21%	17%
Business	0%	16%	17%
Transportation	8%	0%	8%
School	0%	15%	10%

Item Characteristic	ICILS	TEL SBT	TEL Discrete
Item response mode			
Single-selection multiple-choice	10%	18%	39%
Multiple-selection multiple-choice	0%	9%	6%
Drag-and-drop	12%	10%	6%
Select-and-explain	4%	27%	9%
Selection cluster	2%	8%	10%
Constructed response	29%	21%	29%
Action	13%	0%	0%
Flowchart	2%	0%	0%
Creative work or presentation	26%	1%	0%
Other	1%	6%	0%
Scoring level			
2	42%	36%	60%
3	42%	47%	40%
4	6%	13%	0%
5	0%	2%	0%
6	0%	2%	0%
8	3%	0%	0%
10	3%	0%	0%
12	4%	0%	0%
Scoring method			
Human scored	50%	49%	38%
Machine scored	50%	51%	62%

Item Characteristic	ICILS	TEL SBT	TEL Discrete
Design element			
Pictures	22%	19%	39%
Graphs	5%	8%	6%
Data tables	0%	14%	17%
Simulations	4%	6%	6%
User interface navigation	20%	0%	0%
Web pages	30%	9%	5%
Avatar	6%	20%	0%
E-mails	1%	6%	0%
Video	9%	4%	4%
Audio	0%	13%	0%
Text only	1%	0%	0%
Other	2%	2%	24%
Scrolling in item			
No	50%	95%	78%
Yes	50%	5%	22%
Navigation linearity			
Forward only	42%	85%	†
Forward and backward	58%	15%	†
Interactive feature			
No	50%	33%	95%
Yes	50%	67%	5%
Item knowledge type			
Declarative	33%	67%	82%
Procedural	67%	33%	18%
Total	**113 items**	**107 items**	**77 items**

† Not applicable.
NOTE: Detail may not sum to totals because of rounding.

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