

Key Practices for Retaining Undergraduates in Computing*

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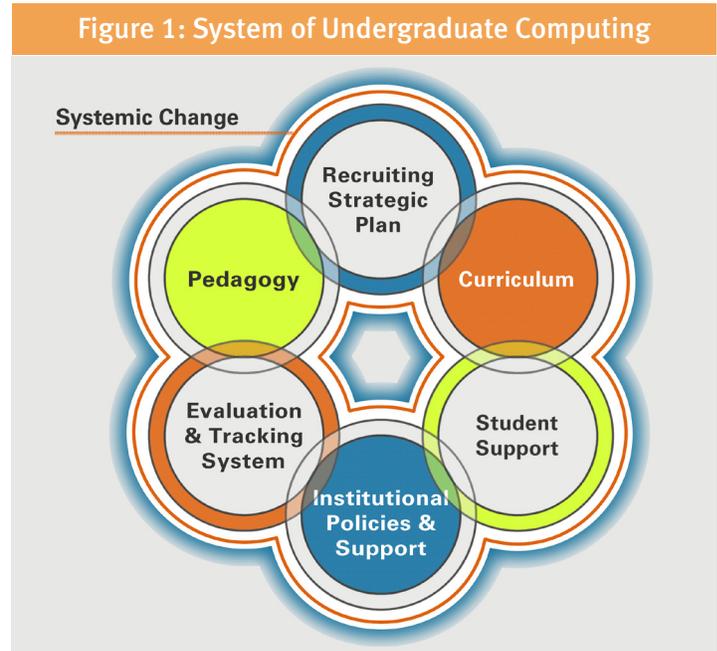
What Research-Based Methods Retain Undergraduates in Computing?

Based in research on women's participation in computing, NCWIT Senior Research Scientists Barker and Cohoon created a model of the system of undergraduate experiences that affect retention in undergraduate programs, shown in Figure 1.

To create and sustain excellence through diversity, effective practices must be mainstreamed into the experiences of all students, not just those of women or minorities (e.g., not extracurricular support groups that target women only). Efforts that support women or minorities alone are effective only for those students who choose to participate and often only as long as funding or a champion is available.

NCWIT advocates a multi-pronged, research-based approach to sustained change in undergraduate computing. Reform initiatives should:

- Integrate teaching methods that create inclusive, collaborative environments in early curriculum.
- Provide early feedback on assignments and the meaning of grades so that students can self-judge whether they are on par with their peers.
- Help students understand how their classes and other experiences (internships, REUs, etc.) contribute to their future identities as computing professionals.
- Align assignments and coursework with student interests and career goals.
- Foster routine, positive student-student and student-faculty interactions that contribute to a sense of belonging in the departmental community.
- Avoid stereotypes and stereotype threats both in and out of class.
- Include visible, high-level administrative support and resources for sustained implementation and evaluation.
- Ensure that efforts to diversify are positively reinforced within the faculty reward structure for promotion and tenure.
- Evaluate efforts to identify what works and what doesn't work; make mid-course corrections to increase success; and communicate findings for increased support and replication by others.



Retention through Pedagogy *Collaborative Learning Interventions*

Recommendations for pedagogy include creating opportunities for student interaction in and outside of classrooms. Student interaction ensures that students hear each other talk about what they are learning (which is different from how faculty talk, often), remove social barriers for easy development of natural and enduring support networks, help all students recognize each other's contributions, and overcome unconscious biases and explicit stereotypes. Student collaboration in and out of classrooms can take many forms and can be graded or ungraded. Examples of collaborative learning opportunities include:

- Peer-led team learning.
- Use of student discussion or problem-solving groups in class.
- Pair programming.
- Affinity research groups.
- “Conversational” classrooms.



See NCWIT Promising Practices and Programs-in-a-Box at ncwit.org for ideas for using pedagogy to retain students. Evaluation instruments are also available.

Meaningful and Relevant Assignments

Students learn more when they understand the relevance of what they are learning to their life experience or their personal or career goals. They are also more tolerant and willing to “stick it out” when concepts are difficult if they know why they are learning what they are learning. Faculty can ensure assignments are relevant and meaningful in many ways, such as by using examples that have broad appeal in explaining concepts, creating the context of programming assignments in some area of interest to students, explicitly telling students how a particular concept is used in different types of environments, and routinely discussing the options, advantages, and rewards of computing careers. To identify topics that have contemporary appeal to students, faculty can administer a short questionnaire. NCWIT cautions against choosing assignments that are meaningful based on stereotypes (e.g., men like violent games, women like to communicate). When assignments are returned, be sure to report the mean, the standard deviation, and the grade expected of someone who is doing well in the class so that students can make reasonable judgments about their fit in the field.



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Retention Through Curricular Reform

The first year or two of a computer science major can be very difficult as students learn very new and abstract concepts. For many students, it is also their first time away from home and they are learning to navigate a new social world. Sometimes more than one difficult course is required during the same term. For example, students may be required to take both introduction to programming and discrete math concurrently. Or, they may be required to take these sequentially, but not understand how one relates to the other. Some departments have carefully examined the impact their curricular requirements have on retaining students and made relevant changes to increase retention—without “dumbing down” the curriculum. Another kind of curricular change departments have made is intended to align with or develop the career interests of students. Research in computer science education suggests that existing curriculum does not appeal to students who do not understand how it will allow them to “make a difference” in the world. Many computer science departments

are integrating either official or unofficial threads, tracks, or majors within their programs to both appeal to students' career goals and to be relevant to specific application areas. Creating multiple pathways into the major or minor can also lead to success. Clearly, some students have very limited experience using the tools they will need for learning (e.g., programming), while others have advanced experience. Creating intensive bridge programs (e.g., at the beginning of the semester) or CS-Zero course that also prepares students for the course normally.



See NCWIT Promising Practices and Programs-in-a-Box at ncwit.org for ideas for using curricular reform to attract and retain students.

Retention Through Student-Student and Student-Faculty Interaction

Research in higher education is unequivocal: student-student and student-faculty interaction leads to student engagement, which leads to improved learning and increased rates of completion. NCWIT Extension Services advocates creating opportunities for the natural development of student peer networks through collaborative learning opportunities in classes and explicit encouragement of students by faculty. However, other types of support are often necessary when a group is severely underrepresented. For example, women's groups can be helpful while other institutional changes are being implemented. In all types of support provided and routine interactions, attention should be paid to inviting and fully including women. For example, faculty can invite undergraduate women to research colloquia and can take turns visiting student lounges informally or attending student organization meetings. Other types of student support include:

- Peer or tier mentoring programs.
- Faculty-student or industry-student mentoring.
- Participation in the Grace Hopper Celebration of Women in Computing Conference; holding Regional Women in Computing Conferences.
- Research experiences for undergraduates (academic year or summer programs).

Avoiding negative stereotypes and “stereotype threats” is important in communicating with students. Stereotype threat occurs when we fear that our actions will confirm negative stereotypes about our “group.” Stereotype threat harms performance and motivation by reducing feelings of competence, belonging, and trust in colleagues. For example, experiments show that White male engineering students get lower-than-usual test grades when told that Asians typically score higher than any other group on math tests. In addition, awareness of others' low expectations for “people like me” prompts us to set harsher standards for our own work and to opt out if we do not meet them.

Keep in mind that:

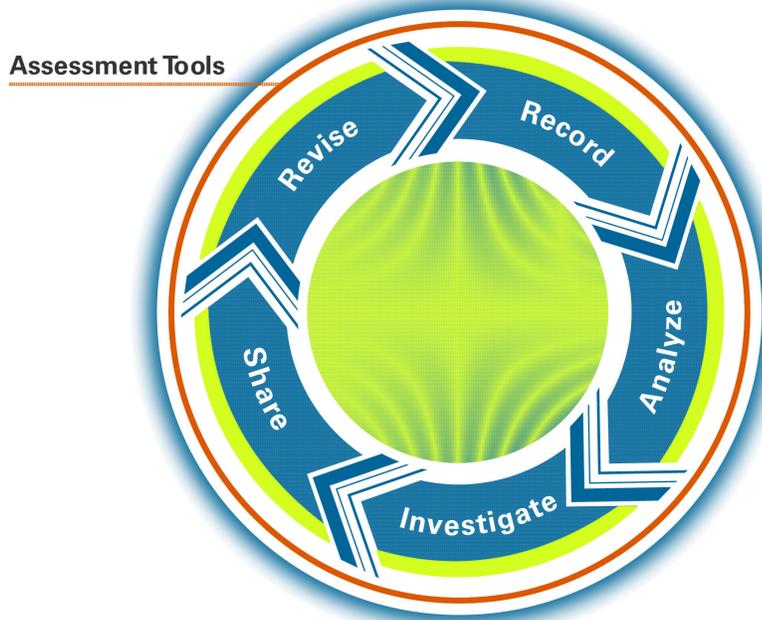
- Well-intentioned comments can have negative consequences if they raise awareness of negative stereotypes. For example, praising a female student by telling her she is as good as her male peers is a reminder that this may have been an unexpected fact.
- Foster a belief that intellectual ability—like a muscle—increases with effort.
- Avoid characterizing a person as a representative of his or her group.
- Foster cooperation to reduce competitive peer interactions and increase feelings of belonging.



See NCWIT Promising Practices and Programs-in-a-Box at ncwit.org for ideas for student-student and student-faculty interaction and ideas for avoiding stereotype threats to retain students.

Constant Improvement Plan: Evaluation and Tracking

Two kinds of evaluation can support a department's goal accomplishment efforts. Tracking student recruitment and retention outcomes can help you to understand whether your combination of efforts is working and how to tweak them to improve progress toward goals. The NCWIT Extension Services Undergraduate Tracking Tool is freely available for keeping track of student participation, broken down by sex, race/ethnicity, and year. Evaluation of specific initiatives can help you to identify whether these are working. The Student Experience of the Major Survey can help you to identify factors in your program that lead to increased or decreased intention to complete the major. Entry and exit surveys are useful for identifying what works for recruitment and students' perceptions of their time spent in the program.



See *NCWIT Extension Services, Promising Practices, and Programs-in-a-Box* at ncwit.org for ideas for evaluating your retention efforts.

NCWIT Extension Services (ES) provides customized consultation services to members of the NCWIT Academic Alliance (AA) for implementing systemic change in their undergraduate programs (UP) in ways that increase enrollment, retention, and graduation of women. To learn about the ES-UP consulting process and ESC expertise, go to www.ncwit.org/work.extension.html, or contact us at es@ncwit.org.