How Do You Retain Women through Inclusive Pedagogy?

Student ability is important, but learning occurs within social environments and it is mediated by the communication norms of those environments. As educational researchers Margaret Eisenhart and Elizabeth Finkel wrote, learning develops when one "changes from novice to expert, newcomer to old-timer, or naïve to mature practitioners in a social practice such as the activities of a science curriculum or an engineering workplace" (p. 8).

Decreased confidence among women is a frequently recurring theme in STEM and IT research. Women are more likely than men to lose confidence in their ability to complete the tasks required for earning acceptable grades, even when their performance is equal to males'. This loss of confidence can result from the suggestion that women do not fit the image of "scientist" or "engineer." We know that students and professors maintain mental models of the types of people who belong and what they can or should contribute. For example, two studies in engineering showed that despite entering their engineering majors with stronger academic preparation than their male peers, women were often considered less capable academically, or even described as "not the real engineering type." Not surprisingly, women in these studies eventually came to view themselves in the same way, resulting in either dropping out or practicing on the margins in their project groups. With repeated (and often subtle) messages that one is not like the other students — not as smart, not interested in the same activities, not a "real" computing major — it becomes difficult to imagine oneself developing the identity of a computer scientist.

Classroom opportunities for holding intellectual conversations can help to alleviate the loss of confidence among women, while allowing them to develop support groups and networks of intellectual support. Hearing other students talk about what they are learning gives women better information for making judgments about whether they in fact do belong there. And, other students hearing women's intellectual talk forces them to recognize that women are competent contributors to the intellectual enterprise.

WHERE WE LEARN SHAPES OUR LEARNING

Both the physical and the social aspects of a learning environment influence student participation and satisfaction, as well as learning itself. For example, when students' seats are bolted to the floor facing a lectern, student collaboration can be inhibited.

An important aspect of a classroom learning environment is the communication climate. When instruction is mainly lecture-based with few or no opportunities for interaction, students have little expectation that they will, can, or should learn from each other. Under these circumstances students may resist different teaching methods such as student-led discussion or small group-work. Studies show, however, that with effective teaching, small group-discussion enables students to effectively internalize and apply interpretive procedures. Hearing other students talk about the concepts being taught has many benefits. Especially important in this process are the supportive relationships and the network of learning partners students can develop. So, despite the years of socialization and expectations that students (and instructors) bring with them, new routines can quickly develop into new norms.

Despite the years of socialization and expectations that students (and instructors) bring with them, new routines can quickly develop into new norms.

RESOURCES

Barker, L. J., Garvin-Doxas, K., & Jackson, M. J. (2002). Defensive climate in the computer science classroom. *ACM SIGCSE Bulletin, 34*(1), 94-99. ACM, New York, NY. doi:10.1145/1060071.1060073.

Eisenhart, M. & Finkel, E. (1998). *Women's science: Learning and succeeding from the margins*. Chicago, IL: University of Chicago Press.

Hiemstra, R. (1991) Aspects of effective learning environments. In R. Hiemstra (Ed.), *Creative environments for effective adult learning* (pp. 5-12). San Francisco, CA: Jossey-Bass.

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The Conversational Classroom (Case Study 1)

Retaining Women through Inclusive Pedagogy

Undergraduate **Graduate**

This intervention, tested and repeated at the University of Colorado with excellent results, is based on the rationale that students could read their assigned books where the content of the course was clearly laid out. They did not also need for the professor to plan and deliver lectures covering the same material. Instead, they needed access to the professor and each other for asking questions, testing hypotheses, exploring new ideas, etc. In short, professors believed that students needed to engage each other and the professor in intellectual conversation about the material. Therefore, the professors facilitated discussions of the material for each class period. That is, instead of lecturing, professors come to class and ask students if they have questions. In this way, the professor requires that students take control over the flow of information.

The first time he used the Conversational Classroom method, University of Colorado Professor William Waite says that students resisted very strongly; their years of socialization made it difficult to change the way they practiced learning. But, it was also difficult for Waite; he came close to buckling under student pressure. After four weeks, however, students began to take responsibility for their own learning.

Computing faculty today face many pressures to integrate collaborative and cooperative learning approaches in courses, increase active participation by students in classes, and increase the participation of under-represented groups in computing. The pressures come from many sources, such as the emphasis on team work by the Accreditation Board for Engineering and Technology, the Joint IEEE Computer Society/ACM Task Force in the "Model Curricula for Computing," and especially, industry. Research in computer science suggests that when a student's educational socialization is dominated by individualized learning and homework, they end up with a preference for working alone, tend to procrastinate, are unwilling to support other students, and have a disregard or lack of understanding of team process. This "guide on the side" teaching technique can overcome students' negative conceptions of collaborative learning.

EVALUATION

Although the examinations and homework assignments given were judged to be identical in difficulty to prior semesters when the course was taught as a traditional lecture course, students in the conversational classroom outperformed the prior semesters' students, both during the pilot semester and a subsequent semester. Not only was student interaction a substantial feature of the course, changing classroom climate (for the better, according to student interviews), but student performance also improved.

GENERAL PRINCIPLES AND ESSENTIAL INGREDIENTS

This teaching model requires that students take responsibility for their learning. They will resist because of many years of deeply ingrained socialization. Professors also must hold out and resist the demands of students to go back to the lecture mode. It is worth it, according to the professors who have implemented this intervention. Not only do students learn the material better, but the course structure also requires that they engage with the professor and their fellow students, two known factors in increasing the retention of women in computing.

RESOURCES

Waite, W., Jackson, M., & Diwan, A. (2003). The conversational classroom. *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education,* 127–131.

Waite, W., Jackson, M., Diwan, A., & Leonardi, P. (2004). Student culture vs group work in computer science. *Proceedings of the 35th SIGCSE Technical Symposium on Computer Science Education,* 12–16.

NCWIT offers practices for increasing and benefiting from gender diversity in IT at the K-12, undergraduate, graduate, and career levels.

This case study describes a research-inspired practice that may need further evaluation. Try it, and let us know your results.

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Designing for Diversity (Case Study 2)

Recruiting Women through Inclusive Pedagogy

Undergraduate

The undergraduate computer science (CS) program at the University of Virginia took several successful steps to improve the recruitment of women from their introductory course into the CS major. The department instituted multiple entry paths that tracked experienced and inexperienced students into different sections and incorporated structured laboratories into the "lecture" portion of the inexperienced section. The instructor repeatedly and explicitly encouraged students to choose a computer science major, used examples and assignments that appeal to diverse student groups, and deliberately established a class culture that extended beyond the course. These actions, together with smaller class size, markedly increased the yield of CS majors, and particularly, women and minority CS majors.

All first-year engineering students at UVA are required to earn credit for CS101, the introductory computer science course. Because it is a service course, the school requires an introduction to programming rather than a survey of computing and its grand challenges. To meet the needs of inexperienced students, a higher proportion of whom are women and ethnic or racial minorities, two special sections, CS101E and CS101X, are offered in addition to a regular CS101. All sections cover comparable content, but the prerequisites differ. CS101E is for students with prior classroom experience with variables and control constructs. CS101E students complete their lab assignments at times of their own choosing in open laboratories. CS101X enrolls students who are unfamiliar with programming. This section integrates lecture with guided, in-class experience in an environment free from the potentially intimidating comparison with more advanced classmates. CS101 is available to any student.

Enrolling only inexperienced students affects course demographics. The Student Demographics table (see top right) compares the population of incoming engineering students in 2005 with the population of CS101X. The course was almost half women, and Black students were over-represented — highly unusual demographics for computing or engineering classes. Also unusual for a UVA introductory computing course was the number of students enrolled in CS101X. Space restrictions limited enrollment to 43 students. During the same semester, CS101 enrolled 356 students and CS101E enrolled 91 students.

Student Demographics

Category	Incoming Students	CS101X
White Men	49%	26%
Asian Men	10%	7%
Hispanic/Other Men	9%	5%
Black Students	6%	23%
Women Students	26%	49%

Because of overlap, the percentages do not sum up to 100%.

Surveys identified applications and examples of interest to students. Based on survey results, and research indicating that female and minority students are particularly interested in applications with obvious benefits to society, CS101X emphasizes examples and assignments related to language translation, psychological testing, health, medical diagnosis, and games.

Other pedagogical practices are also designed to be inclusive and attractive to female and minority students. The instructor brings women professionals to discuss their careers. The instructor also routinely expounds on the breadth of options, advantages, and rewards in a computing career. Classroom discussion is routine and offers opportunities for students to learn each others' interests and activities.

CS Major Yields From Underrepresented Groups

Category	CS101X	CS101E	CS101
Minority	49%	26%	3%
Women	10%	7%	5%

The results from the CS101X initiative are student grades comparable to previous CS101 grades, but with more students, more women, and more minority students choosing a CS major. From the beginning to the end of the semester, CS101X increased the number of its students intending a CS major from one to eight. The CS Major Yields table shows striking differences in course success in attracting underrepresented students to a computing major.

RESOURCES

For more information contact Jim Cohoon at cohoon@virginia.edu.

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Equal Access: Inclusive Strategies for Teaching Students with Disabilities (Case Study 3)

Recruiting and Retaining Women through Inclusive Pedagogy

K-12 Education **Undergraduate**

More students with learning and physical disabilities are in the educational pipeline than ever before. Being aware of the issues, tools, and services for students with disabilities makes it easier for them to learn and for you to teach them. Below is a summary of tips from *Equal Access: Universal Design of Instruction*, a resource provided by DO-IT(Disabilities, Opportunities, Internetworking, and Technology) at the University of Washington. DO-IT's mission is to increase the successful participation of individuals with disabilities in challenging academic programs and careers, including science, engineering, math, and technology.

> "These communication hints will help you get started in a conversation with a person with a disability. Every situation is unique, so be flexible and willing to learn."
>
> ***Richard Ladner,*** *University of Washington Department of Computer Science and Engineering*

HOW CAN YOU ACCOMMODATE STUDENTS WITH DISABILITIES?

- Make sure that assistive technology can be made available in the computer lab.
- Invite students to meet with you and discuss disability-related accommodations.
- Ensure physical access to all facilities.
- Arrange instructional spaces to minimize distraction and maximize visibility and comfort.
- Ensure that everyone can see and use equipment and materials safely and effectively.
- Learn campus procedures for accommodation requests (e.g., arrangement of sign language interpreters).

HOW CAN YOU COMMUNICATE EFFECTIVELY WITH STUDENTS WITH DISABILITIES?

General

- Ask a person with a disability if he or she needs help before providing assistance.
- Speak directly to the student, not through his or her companion or interpreter.
- Refer to a person's disability only if it is relevant. Always mention the person first and then the disability. "A man who is blind" is better than "a blind man" because it puts the person first.
- Avoid negative descriptions of a disability. For example, say "a person who uses a wheelchair," not "a person confined to a wheelchair."
- Never interact with a person's guide or service dog without permission.

Blind or Low Vision

- Be descriptive. Say, "The computer is about three feet to your left," not "The computer is over there."
- Verbally describe all of the content presented with overhead projections and other visuals.
- Offer persons with visual impairments your arm rather than grabbing or pushing them.

Learning Disabilities

- Offer directions or instructions both orally and in writing. If asked, read instructions to individuals who have specific learning disabilities.

Mobility Impairments

- Position yourself at the approximate height of people sitting in wheelchairs when you interact.

Speech Impairments

- Repeat what you think you understand and then ask the person with a speech impairment to clarify or repeat what you did not understand.

Deaf or Hard of Hearing

- Face people with hearing impairments so they can see your lips.
- Speak clearly at a normal volume.
- Use paper and pencil if the person who is deaf does not read lips or if more accurate communication is needed.
- Ask students in groups to raise their hands when they speak so that their deaf peer knows who is speaking.
- When an interpreter voices what a student who is deaf signs, look at the student, not the interpreter.

Psychiatric Impairments

- Provide information in clear, calm, respectful tones.
- Allow opportunities for addressing specific questions.

RESOURCES

Burgstahler, S. (2010). *Equal Access: Universal Design of Instruction*, University of Washington. The communication tips shared above are used with permission of DO-IT.

Sevo, R. (2011). *Basics About Disabilities and Science and Engineering Education*. Georgia Institute of Technology.

http://www.washington.edu/doit/

http://www.washington.edu/doit/Resources/technology.html

http://www.washington.edu/doit/Video/index.php?vid=12

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This case study describes a research-inspired practice that may need further evaluation. Try it, and let us know your results.

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Framing a Supportive Classroom Climate (Case Study 4)

Retaining Women through Inclusive Pedagogy

Undergraduate

Professor Melissa O'Neill at Harvey Mudd College observed a vexing problem in her data structures course: a few outspoken students often created a caustic classroom climate. They would typically sit in the front of the class, shoot up their hands to answer every question, and blurt out comments. These displays of prowess made competition the norm — and made it harder for Professor O'Neill to get other students to speak. In course evaluations and during office hours, students said that class was dominated by "loud, pedantic" students and that they "felt dumb" asking questions. Yet conversations with the quieter students revealed that not only were they not dumb, they knew at least as much as their vocal peers. To overcome this problem, Professor O'Neill developed a method for explicitly framing a supportive classroom climate. From the beginning of the term, she makes salient what is important, what she expects students to feel about class, and how she expects them to behave. These expectations must be reinforced throughout the term, however, to avoid backsliding into old routines. O'Neill maintains the frame in her teaching choices, using a turn-taking approach for speaking, small group discussion and problem solving, and collaborative learning in labs.

WHAT IS FRAMING?

An interpretive frame is a set of unspoken beliefs and assumptions for interpreting situations. A frame also implies that certain events can be expected, but not others. For example, at the end of class time, it is expected that even when the professor is still talking, students will (noisily) pack up their materials to leave, signaling the end of class to the professor. Yet this behavior would be considered odd (if not rude) when 20 minutes of class remain.

Framing is explicitly creating a perspective that will strongly influence how students interpret events in class. For example, faculty can say that students with prior knowledge of the content won't learn as much in this class or can't show as much learning as others. If reinforced, these statements can create the expectation that students should be more concerned with new learning rather than with what they already know, and that students' prior knowledge is valued less.

TURN-TAKING: IT'S IN THE CARDS

Create a deck of "trading cards" with students' names and photos. At the beginning of class, shuffle the deck to randomize it. When you ask a question of students, turn over the top card: it's that student's turn to answer. (Besure to ask the question before turning over the card to avoid the perception that certain students are picked on.) The student has three choices: answer; ask a clarifying question; or "pass" (in this case, insert the card into the deck just a few cards down instead of putting it at the bottom). If a student gives a right answer, talk to them about why it's right. If a student gives a wrong answer, praise him or her for trying and talk about why it's wrong. Make your classroom a safe sanctuary for making mistakes by reinforcing a trial and error approach to learning.

Students report that this is an unbiased way of being called on. It also helps to minimize students "showing off," since it's not their turn, and can draw more reserved students into active participation.

RESOURCES

Barker, L., O'Neill, M., & Kazim, N. (2014). Framing classroom climate for student learning and retention in computer science. *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*. ACM, New York, NY. (pp. 319–324). doi:10.1145/2538862.2538959

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Framing a Supportive Classroom Climate (Case Study 4)

Retaining Women through Inclusive Pedagogy

Undergraduate

Framing Goal	Beginning of Term: Set Up the Frame	Throughout the Term: Maintain the Frame
Expected Knowledge is Explicit	Make explicit what you expect students to already know and what you don't expect them to know. Let students know that learning new things is valued, while parroting back what they already know is not. Implementation Idea: O'Neill uses a pre-course survey on which students rate their knowledge about key course concepts ("know nothing" to "know a lot"). By presenting the survey results back to students on the first day, she can explicitly demonstrate the range of knowledge and comment on whether they are expected to know certain concepts or not.	Have a plan for dealing with vocal students who blurt out tangential or irrelevant comments or who try to answer every question. Implementation idea: Talk to students outside of class when they are not following the "rules." Remind them about your goals for the course. Make them your ally. Avoid embarrassing them in front of the whole class, since that might lead other students to distrust you.
All Students Speak in Class	Discuss your expectations about how vocal or reserved students should be. Explicitly state that every student is expected to respond to questions. Ask those who are typically reserved to be more vocal and those who are vocal to be more reserved. Implementation idea: O'Neill asks students their usual style on the pre-course survey, shows them that they are part of a larger group of people like themselves, and then asks them to go outside of their comfort zone.	Use a turn-taking approach to reduce student anxiety about their status among peers. All students speak when it is their turn. Implementation idea: see box "it's in the cards"
Wrong Answers & Mistakes are Expected and Valued	Make the classroom a safe place to make mistakes and propose wrong answers. Implementation idea: Ask students to think about whether they like making mistakes or hate it. This creates the opportunity to talk about the value of making mistakes for learning and to reinforce a growth mindset. It also creates the opportunity to remind students that everyone is wrong sometimes, and though they may be concerned with how they'll look to other students, chances are that the other students are more worried about themselves.	When students give a wrong answer, be sure to explicitly state that it is wrong, but praise the opportunity to explore why it is wrong. Routinely reverse students' beliefs that wrong answers are embarrassing; rather, mistakes are an important part of scientific discovery. Implementation idea: Say, "that is not the right answer, but I am so glad that you brought it up, because it is a common misconception and gives us the opportunity to come up with the right answer."
Students are Part of a Learning Community	Describe your expectations for students as learners (e.g., partners in peer learning, how to give you and each other feedback, etc.), and what they can expect from you. You can subtly imply that they *want* to learn rather than imply that there is material they *have* to learn. Implementation idea: Ask students to write responses to "What excites you about taking this class?" and "What will you want help with?" in a one-minute paper in class or in a survey. Collect papers and randomly (and anonymously) present responses. Be sure to avoid judgments in discussing responses.	Use teaching approaches that require that students take ownership of their learning and co-learn concepts. Small group approaches can take the pressure off of students who worry about making mistakes in front of the class, can reduce their reliance on you as the source of all learning, and allows students to articulate their learning to classmates in their own words. Students will also implicitly gather information about "who knows what" in class. Implementation ideas: Add structured, collaborative approaches like small group discussion to lecture or use peer-led team learning. Use pair programming in lab. At Harvey Mudd College, O'Neill found that fewer students came to office hours and had better-articulated questions when she required pair programming.