ARIZONA STATE UNIVERSITY

Improving Student Success and Retention Through Active and Adaptive Learning Strategies

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A CASE STUDY OF ACTIVE LEARNING IN ENGINEERING

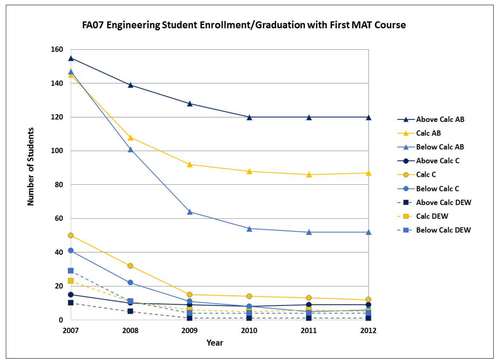
We are currently in the middle of a comprehensive evaluation of the extent of implementation of *evidence-based instructional practices* and the factors that influence them in the Fulton Engineering Schools at Arizona State University (ASU). Enrollment in engineering at ASU has increased from 750 freshmen in 2007 to an estimated 2,000 in 2014, and retention of these new recruits is a primary institutional goal.

Current evaluation of freshman courses shows that persistence to graduation depends greatly on freshman mathematics success. A multinomial logistic regression was performed on level of course and course grade for all freshman STEM courses. Results show that mathematics performance is a critical indicator of engineering persistence.

If, for example, a student from the 2007 cohort took a course that was above Calculus 1 for their first math course they were 2.3 times more likely to be retained in Engineering than a student who took Calculus 1. If a student took Pre-calculus or another course below Calculus they were less than half as likely to persist in Engineering than those who took Calculus $p < 0.001$.

For the main effect of Grade, if a student received an A or B for their first mathematics course regardless of which course they took, they are 6.5 times more likely to persist than someone who received a D, F, or W in their first mathematics course $p < 0.001$.

These findings are similar but less pronounced for Physics and Chemistry, and non-existent for freshman Engineering courses.



STRATEGIES FOR INCREASING ENGINEERING PERSISTANCE

To improve student persistence new introductory engineering curricula were designed, instructional faculty hired, and space and resources renovated to facilitate active learning. Modular laboratories have been built specifically for housing Freshman courses (for a similar approach in Biology, see case study this poster).

All freshman students are engaged in E2 Camp!

All 2,000 Engineering freshmen attend one of eight 3-day camps held in the weeks leading up to Fall classes. E2 engages first-year students in the Ira A. Fulton Schools of Engineering in activities that introduce them to ASU and Fulton Engineering culture.

The goals of E2 are:
- To identify as a part of the Ira A. Fulton Schools of Engineering community.
- To build a sense of camaraderie among students.
- To provide opportunities for students to practice teamwork skills and introduce them to a culture of teamwork.
- To cultivate leadership in our upper-division students.

Professional development and support for active learning for faculty!

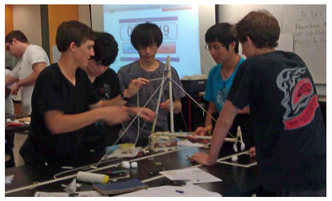
Since 2007, faculty have been engaged in active learning strategies including facilitating group work, hands-on laboratory design, two-way feedback, and use of learning technologies.

Example--Two-way feedback:
Faculty assess students' "Muddiest Points" following class sessions. Students provide feedback to professor on concepts they find hard to understand. Within 24 hours, a report is developed that traces the concepts students' self-assess as being difficult, and those concepts faculty have not adequately developed. Strategies for follow-up include:
- Providing supplemental videos examining problematic content to assist student study.
- Assigning TAs to follow-up individually with students based on their responses.
- Redesigning lecture or lab sections to address common problems.
- Scheduling special study sessions in the evening to address difficulties

It is also possible now to easily and efficiently collect and review Muddiest Point reflection responses via the web on the cyber-enabled Concept Warehouse web site http://cw.eduDiv.org.

SUMMARY OF INTERVENTIONS CURRENTLY BEING IMPLEMENTED

- Development of a pre-engineering bridge program that brings all students in Calculus-ready (predicted 2x increase in persistence for underprepared students).
- New curriculum and materials for Pre-Calculus.
- Adaptive assessment.
- Introduction of supplemental instruction and learning assistants in Physics.
- Increase in trained mathematics tutors.



Middleton's Freshman Engineering Students engaged in "Build an Elbow" activity. Students are given newspaper, string, and common household objects and required to build a device that can pick up objects and move them from place to place. Emphasized biomimicry, leverage and mechanical advantage, tensile structures, and the engineering design process.

New instructional spaces facilitate problem-based learning. Students are required to utilize the engineering design process, and STEM content to design, build, and test unique projects that address a problem of importance to society. Here, Professor Attard (purple) oversees students' designs for earthquake-proof buildings.

The Dean, Paul Johnson, joins student teams at E2 camp. The camp is designed to introduce students to each other, Engineering faculty, and engineering opportunities at ASU in an informal, fun environment. Students take their first class session at E2 Camp.

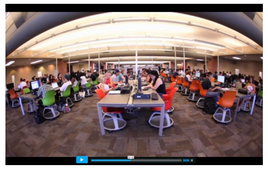
Upper-Division students are trained as peer mentors and teaching (learning) assistants. All Freshman Engineering classes utilize peer mentors. Physics is implementing a Learning Assistant model. Mathematics (see right) is developing adaptive learning systems to facilitate freshman success.

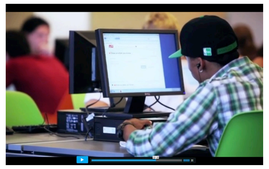
A CASE STUDY OF ADAPTIVE LEARNING IN MATHMATICS

With more than 70,000 students, ASU is the largest public university in the United States. As a research university committed to improving access to education, ASU was strained by the large number of enrolled students — each with diverse needs, interests, and educational backgrounds — who were not college-ready in mathematics, a key predictor of university success. ASU saw a high correlation between students who succeeded in developmental math and overall academic success. Students who earned an A, B, or C had 50% higher persistence rates (i.e. retention through graduation) than those earning lower grades. Unfortunately, more than 30% of students failed to receive a C or higher in ASU's developmental math course.

INTRODUCTION OF ADAPTIVE LEARNING

ASU developmental math students now use Knewton Math Readiness, a developmental math course powered by the Knewton platform and aligned with the Common Core Standards for Mathematics. As students work through online math lessons, Knewton analyzes vast amounts of anonymized data to figure out what a student knows and how they learn best. Then Knewton recommends what concept in the course each student should study next, personalizing the educational experience and helping students at any level succeed.

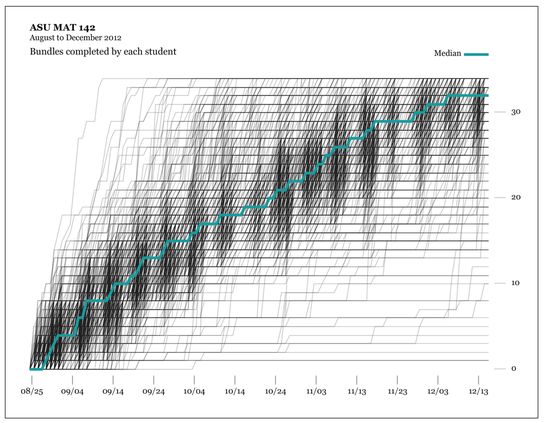




Adaptive learning lab for students. Instructors and learning assistants are also available if a student has questions during the session. Students also have access to the learning bundles online. However, tests must be taken in the learning lab.

HOW ADAPTIVE LEARNING WORKS

Knewton technology enables an entire class to work through material in a sequence and pace customized for each individual. As ASU's students progress through their developmental math course, the Knewton platform analyzes data behind the scenes to continually assess students' mathematical proficiency. Knewton then recommends what concept within the online course a student needs to work on next, creating a continuously updated and personalized learning path for each student. ASU's faculty used Knewton's real-time reports to detect gaps in knowledge, create adaptive study plans for each of their students, and focus lessons around concepts where students needed the most help. Students worked through the course at their own pace with their instructor's guidance. Instructors can see which students are off-track, search for individual student performance metrics, or view trends across an entire group of students to determine which concepts are most difficult across the board. The course goal is to complete the requisite number of lessons at a certain performance standard. Each student must also pass a final exam administered by ASU.



OUTCOME

After two semesters of use with over 2,000 developmental math students at ASU, course withdrawal rates dropped by 56% and pass rates increased from 64% to 75%. Almost half of students finished the course four weeks early, allowing them to advance immediately to the next level upon mastering course concepts.

	FALL 2009 - SPRING 2011 (without Knewton Math Readiness)	FALL 2011 - SPRING 2012 (with Knewton Math Readiness)
PASS RATES	**64%** (2,419)	**75%** (1,565)
WITHDRAWAL RATES	**16%** (613 students)	**7%** (138 students)
STUDENTS FINISHING EARLY	n/a	**45%** (~942 students)
TOTAL NUMBER OF STUDENTS	**3776**	**2095**

Triangle-shaped tables provide student pairs the ability to interact with each other as well as engage other students at the table. White boards line the walls of the room. Four large projection screens are located around the room and can be used to share work from any of the student stations.

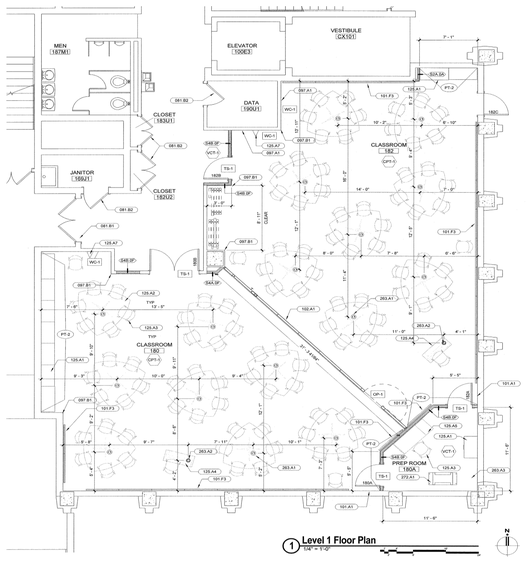
Screens can be shared between computers at each pod and across all the computers in the laboratory as well as to any of the four projection screens.

Paired students work on active learning modules. The modules can be made available online for students to review, and work on outside of class.

Active learning laboratory connected with a companion classroom at Leuphana University in Lüneburg, Germany - part of the Global Classroom project. Teams are composed of students from both institutions. The three-semester course focuses on sustainable cities and requires students to collaborate on multiple projects.

A CASE STUDY IN BUILDING AN ACTIVE LEARNING SPACE FOR BIOLOGY

Both active and adaptive learning strategies require a change in the traditional classroom and laboratory space. Finding appropriate locations for these spaces can also be a challenge. The university is currently building active and adaptive learning spaces within the university libraries as well as some academic units. The School of Life Sciences recently remodeled a space previously used to house a lichen collection that has been moved to central museum collection facility. The new space accommodates up 108 students and provides highly collaborative tools for students and instructors. The room can also be split into two small teaching labs.



KEY FEATURES OF AN ACTIVE LEARNING SPACE

Planning active learning space requires:

Learning Features
- Ubiquitous White Board Space
- Four Independently Controlled Projectors -> Flexibility
- Mobile Wall -> Two Classrooms

Pod-based Learning Space
- 18 Pods, Six students each
- Triangular shape encourages work in pairs and small groups
- Spatial Awareness
- -> Increased Collaboration

No Front
- Room built for active learning
- Encourages instructor role as facilitator, not lecturer
- Encourages greater student engagement with content

Technology
- Fifty 23" Touch Screen PCs (one per student pair)
- Each PC acts as Instructor Station
- Ability to share screens across all PCs (LearnSpace by Pixelture)
- -> Increased Flexibility and Collaboration
- Gigabit Network Infrastructure enabling meaningful digital experience

Video and Microphone Equipment
- Support faculty development of teaching
- Collect data on how students learn
- Collect data for educational research

SUMMARY OF CASE STUDIES

Both active and adaptive learning strategies require investment in technology, space, faculty, and in some cases additional teaching assistants. The work at ASU has not be driven by cost saving measures. Instead, the projects and programs are seen solely as methods to increase student success and retention. The case studies highlighted here are in their early stages. Evaluations of the programs are ongoing and the impact on student retention will require additional years of study. Some of our early results are promising. The adaptive math courses continue to be reviewed and refined. In addition, new adaptive non-major courses in biology, chemistry, economics, physics, and psychology are under development. The first pilot courses will be launched the fall of 2014.