

ASU
MATH TRANSFORMATION:
ACHIEVEMENTS AND PLANS

ASU GOALS

The Arizona Board of Regents' instructions include:

- Lead the design and launch of “Math Transformation” to eliminate math as a “rate limiter” for student success in both STEM and all other areas of study.
- Include the design and launch of a learning approach using adaptive learning platforms capable of changing ASU course success rates to more than 80% mastery from around 50%.
- At least 3 large scale deployed courses must be transformed.

EVOLUTION OF ASU'S ADAPTIVE LEARNING PLATFORMS

ASU was the first university to introduce courseware that was truly adaptive in 2011, spurred by a critical need to improve proficiency in foundational math skills.

- Too many students failed to advance to a degree because they were unable to pass a college level math course.
- All attempts to solve the problem failed until installation of adaptive learning.
- As we usually use the term in math:
 - ✓ adaptive learning means courseware that progress students through learning objectives on a personalized path, measuring each student's proficiency on each learning objective.
 - ✓ If the student attains the required proficiency (normally 90%) on a learning objective they progress to the next lesson. If not, they review. If they again fail to get the required proficiency score, they can be remediated lesson by lesson.

Adaptive Learning vs Lecture

	Lecture		ADAPTIVE
- Lesson Plan	Fixed	→	Variable
- Presentation	Group	→	Individual
- Content	Common	→	Personalized

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Evolution: Phase 1

Three Intro Math Courses Transformed to Adaptive Learning in 2011

The three courses transformed to adaptive learning were:

- **MAT 110, Foundational Math**
 - ✓ A non-credit course to prepare students for college level math.
 - ✓ One of the two greatest math course challenges nationwide.
- **MAT 117, College Algebra**
 - ✓ The other greatest challenge nationwide in math.
 - ✓ A required course for students unprepared for Calculus.
- **MAT 142, College Mathematics**
 - ✓ The required course for certain majors such as the arts, humanities, some social sciences and others.
 - ✓ Less algebraic content than MAT 117.

Characteristics of the Transformation

- The three classes were transformed to adaptive learning with a personalized path, measuring each student's proficiency on each learning objective.
- Problem solving skills emphasized
- Each class doubled in size to as many as 100 students per section because of the instructional efficiencies provided by the courseware.
- Content was standardized so that every student in each course section confronted exactly the same material; material could not be trimmed at the discretion of the instructor.
- Grading was standardized so that individual faculty could not curve the grades as they chose.
- Students required to pass from lesson-to-lesson by attaining mastery on all lessons, usually 90%, in addition to grades on exams. Previously, students could get a passing grade while having large gaps in their mastery of some content.
- ***Generally speaking, these changes made grading more stringent.***

Student is led through the course

- Know what they have accomplished
- Know what is next
- Know where they are supposed to be

ASU MAT 194: Enhanced Freshman Mathematics **BETA** Help | Back to Course Home MY DASHBOARD

Welcome, Knewton

HOW THIS COURSE WORKS

Next activity

? Workshop: Inside a lesson

From: Getting started > Using this course > How this course works

Let's go >

STATUS ?

Incomplete

This course has ended. You did not complete the course requirements in time.

BADGES ?

0 of 7

SUBJECTS COMPLETED

- Getting started
- The number system
- Equations & expressions
- Ratios & proportions
- Statistics & probability
- Geometry
- Functions

ASU Math Redesign Adaptive Learning The Classroom



Students are engaged.



An instructor and 4 assistants answer individual questions.

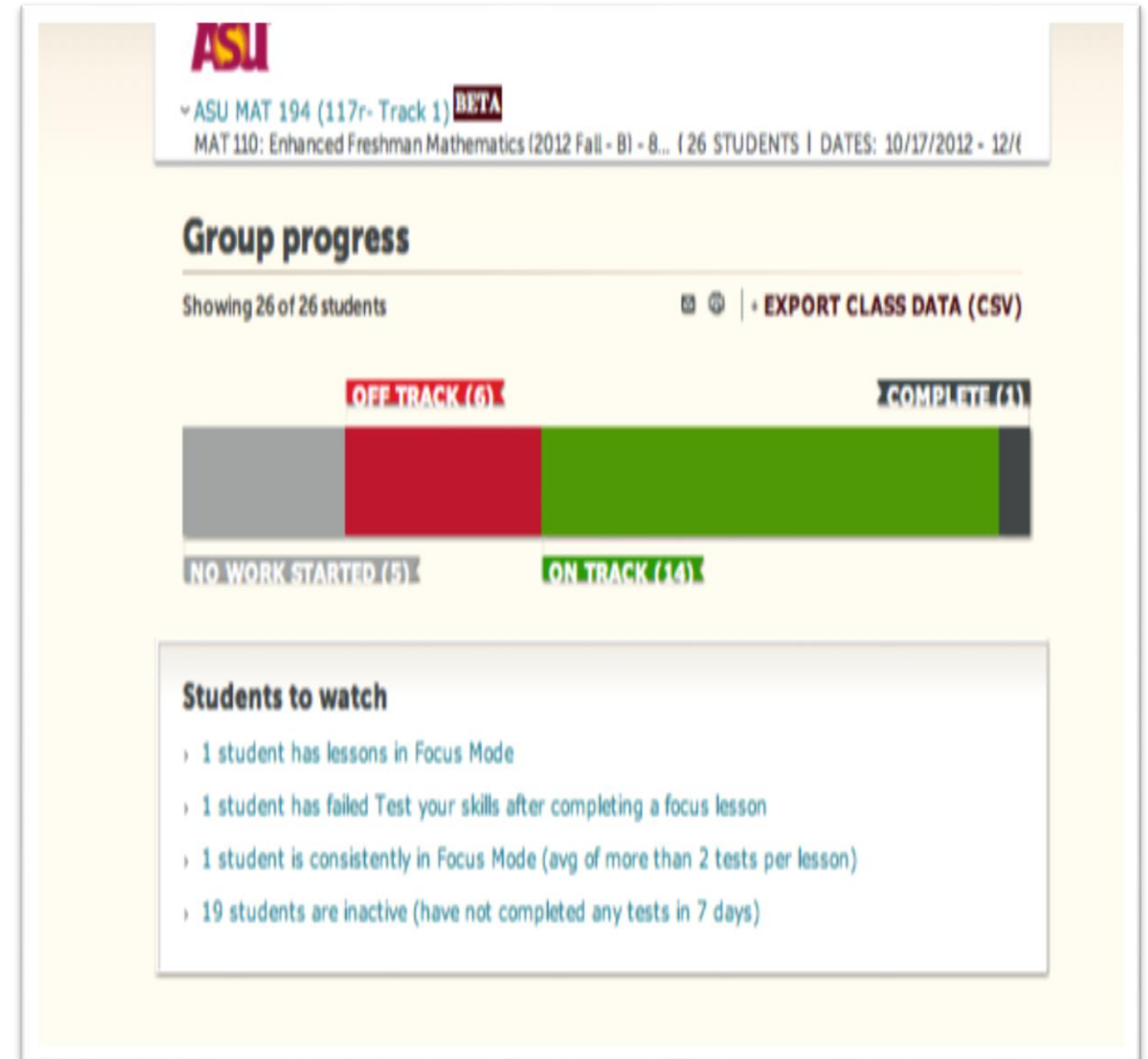


Student attendance is strong.

Faculty Efficiencies

Instructor knows who needs assistance

- How the class is doing
- Drilling deeper in the dashboard, how each student is doing
 - ✓ Who is doing fine
 - ✓ And who needs assistance
 - ✓ And the lesson in which the student is struggling



Student Success

Usually, grade performance is better in the Fall in all three courses because more highly qualified first-time freshmen take the courses in the Fall.

Recall, post-adaptive, content and grading are standardized and grading is more demanding, usually requiring 90% proficiency on all lessons.

MAT 110: Grades definitely improved post-adaptive.

MAT 117: Post-adaptive, performance fluctuated year-to-year in MAT 117, the most difficult of the three classes; but on balance declined, albeit with a doubling of class size and more stringent grading standards.

MAT 142: Grades fluctuated year-to-year, but was relatively unchanged on balance over the academic years, albeit with a doubling of class size and more stringent grading standards.

The % of students earning an A,B or C

- Pre-adaptive learning AY 2009-10
- One year after the transition, AY2012-13*

	Pre-adaptive		Post-adaptive	
	F09	Sp10	F12	Sp13
MAT 110	69%	52%	83%	69%
MAT 117	69%	57%	63%	51%
MAT 142	82%	71%	83%	79%

* To keep comparisons consistent, grades are reported for on-campus sections as the dominant option available to students when the transition to adaptive learning took place.

Lessons Learned

Problems became apparent in this time period, requiring some changes.

1. Instructor training and their experience in teaching in this manner were paramount to success.
 - Turnover in instructors plagued the earliest years.
 - Eventually, this was rectified as experienced course coordinators took responsibility for monitoring, mentoring and training less experienced instructors.
 - Overtime, a core of more permanent instructors were retained from year-to-year.
2. There also were external changes that influence year-to-year student performance such as the change in the math placement exam and the use of i-courses. As a consequence, student success rates can and did fluctuate between years as these external factors changed.
3. A more persistent problem -- this was the dawn of the technological development in adaptive learning courseware, led by ASU. The technology was still catching up to the instruction throughout these early years; and MAT 117 was especially plagued by this problem.

EVOLUTION: Phase 2 2016

The courseware for MAT 117 had not been updated significantly by the original vendor since it was launched in 2011. New ALEKS (McGraw Hill) courseware had just been modified at “instruction quality”; and planning began in AY15-16 for the transition to ALEKS in MAT 117.

- The advantage of ALEKS is its superior capability to remediate not only within the course content, but also remediate with content that is pre-requisite knowledge below the starting level for the course.
- During this time, our own instructional videos were integrated into the ALEKS platform. Additionally, new short videos produced “by students for students” were installed to provide real-time tutoring on specific topics around the clock.

Three Courses Collapse to TWO

The precision at which ALEKS can remediate with pre-requisite content as well as regular course content led to a radical departure from the national practice.

- MAT110, foundational math, was eliminated in spite of the success in this course which started with a A-B-C rate of 66% prior to adaptive learning and finished above 85%.
- Now, students who would have placed into foundational math in the past enroll directly into the appropriate credit bearing courses, MAT 142 or MAT 117.
 - ✓ ALEKS possesses the capability of assessing a student's mastery of content, topic-by-topic. If a student needs foundational remediation in any particular topic, ALEKS can deliver it as needed and when needed.
 - ✓ Some students may need most of a semester of remediation. They earn continuing credit (a Z grade) in their class and finish the course the following semester.
 - ✓ Many students need much less remediation and they can complete in one semester what would have taken two semesters in prior years.
 - ✓ Additionally, students will not be placed into a remedial class. Studies find that remedial classes create a self-fulfilling feeling of failure; and for students insufficiently resilient, often lead to higher withdraw rates from the university.

Student Success: Phase 2

MAT 117: Student success in MAT 117 jumped to 78% in Fall16 and is projected at 77% in Spring17; *this in spite of having students who previously placed into foundational math main-streamed into the challenging MAT 117 class.*

MAT 142: Student success in MAT 142 improved over the combined Fall-Spring semesters, although MAT 142 has yet to be converted to ALEKS; *this in spite of having students who previously placed into foundational math main-streamed into the course.*

Enrollment in what were three classes in Fall 15 went from 4,150 to 4,400 as the three classes were collapsed into two in Fall16. But Spring enrollment fell from 1,945 in Spring 16 to 1,217 in Spring 17. This means significantly more students completed in one semester what many did over two semesters in previous years; *an important step in achieving the goal to eliminate math as a “rate limiter” for student success in both STEM and all other areas of study.*

	Pre-ALEKS		Post-ALEKS	
	F15	Sp16	F16	Sp17
MAT 110	85%	87%	X	X
MAT 117	62%	64%	78%	77%*
MAT 142	80%	64%	80%	70%
Total Enrollment	4,150	1,945	4,400	1,217

*Forecasted based on the expected conversion rate of Z to a passing grade

Alternative Measures of Success

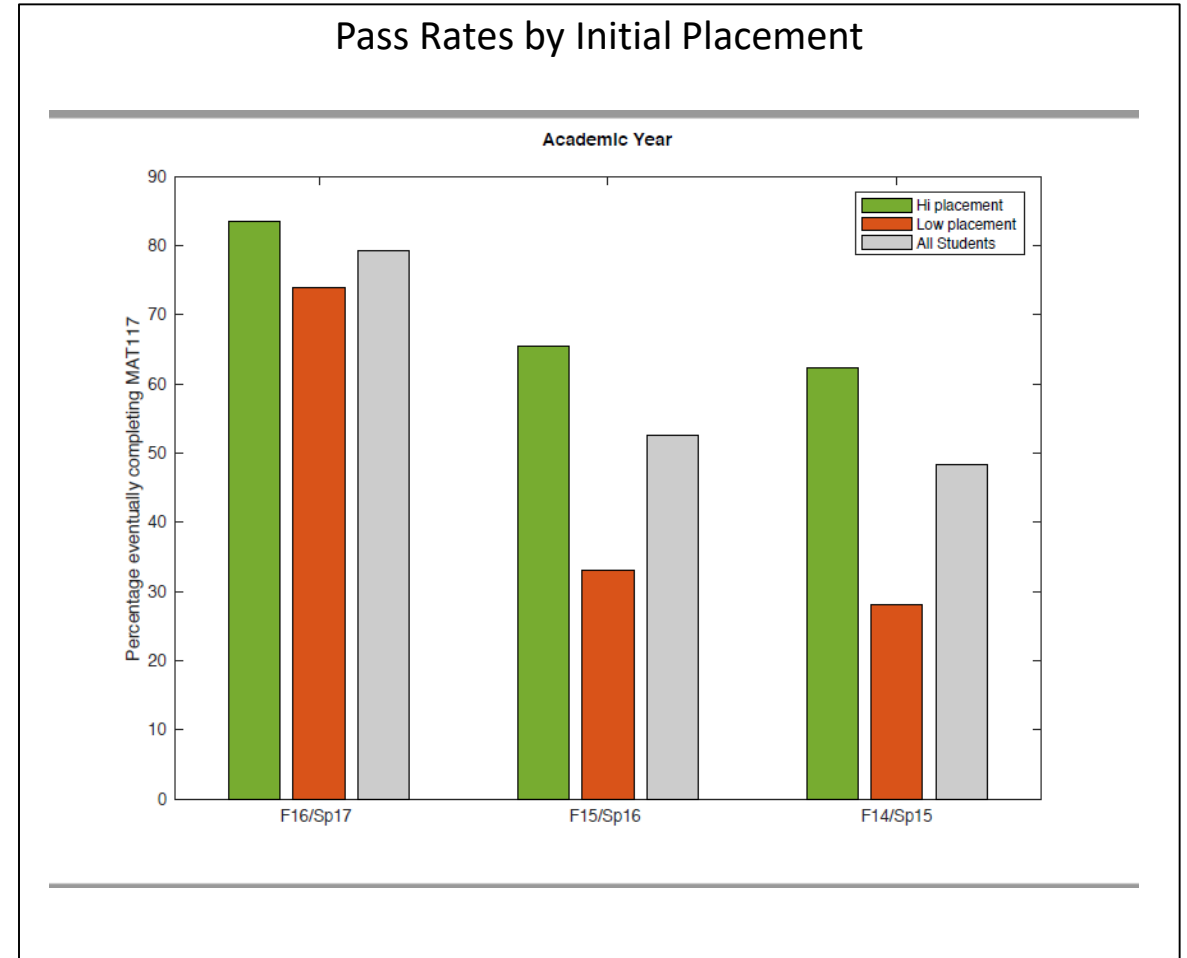
The success rate as calculated in the previous tables is the most common measure of course success used nationally. But these results understate the success of the courses in some important ways.

- For instance, students can choose a W or Z grade in MAT 117 and not complete the course for reasons unrelated to class performance.
 - ✓ The large majority choose a W or Z grade with the intent of completing the same course the next semester; and a significant number achieved this goal.
 - ✓ But others drop the course because they change their major to one that requires MAT142 instead of MAT 117.
 - ✓ Still another segment of students start at ASU in the Fall semester but do not re-enroll at ASU for the Spring semester for a large number of reasons. Clearly, they will not be able to convert to a passing grade by Spring.
 - ✓ The success rate in MAT 117 goes to 87% once adjustment is made for those who choose a Z or W with the intent of enrolling in MAT 142 in a new major or the intent of withdrawing from ASU entirely. When Online students are included, the success rate is 83% in Fall16 after these adjustments.
- Another perspective on grade performance is to calculate the percent of students who enrolled in MAT 117 and received a D or E grade. That figure is only 3.2% for Fall16.

Alternative Measures of Success (cont)

Closing the Achievement Gap

- Another consideration per the goal to eliminate math as a “rate limiter” is to examine how students perform by initial preparation.
- Previous to the migration to ALEKS, students completed the course at significantly lower rates, as already mentioned. But this is especially true of those with low placement scores.
 - ✓ In previous years, students with initially low placement scores passed MAT 117 only 31% of the time, about a 33 point gap compared to those with satisfactory placement scores .
 - ✓ In AY16-17, 83.5% of the students with satisfactory placement scores passed while students with initially low placement scores eventually passed at a rate of 74%, substantially closing the achievement gap.



Alternative Measures of Success (cont)

Mastery

- Place holder ACHIEVING COURSE SUCCESS RATES OF MORE THAN 80% MASTERY – awaiting data
- As already indicated, the adaptive learning system can measure proficiency for each learning objective in the course. Often, a rule of 90% proficient is used. Show average proficiencies over all learning objectives for all students -- This would have to be only measured for students who complete the course.

Phase 3

2017-18 and Beyond

ASU's innovation leadership will remain intact even though it will be much easier for other universities to obtain courseware than it was for us to develop it. Four areas of frontier development are either in-progress or soon to begin.

- Development of adaptive learning courses in pre-calculus, calculus for engineers and calculus for business
- Massive open math course for credit: GFA courses
- Connected Courses
- Transfer to grades 9-12

Transformed and New Courses

- MAT142, already an adaptive learning course, is being migrated to the ALEKS platform in Fall 17 as a pilot in a few sections of the course; and converted entirely to ALEKS in Fall18 once the courseware is de-bugged. As it did for MAT117, ALEKS will provide a superior adaptive learning experience for students in MAT142; and it will provide superior measurements of proficiency on every learning objective for every student.
- Also using ALEKS, MAT 170, pre-calculus, currently is being readied for the Global Freshmen Academy (GFA) using ALEKS. As the course is also being readied to be taught on-campus in this format in Fall17, the development efforts ongoing for the GFA will greatly accelerate course development across the other ASU platforms. This will become the fourth large enrollment class transformed to an adaptive learning platform, although it will be the third surviving course. MAT 170 is an important pre-requisite course for many STEM students not yet prepared for Calculus.
- The business calculus course, MAT 210, and the multi-course sequence in engineering calculus are slated for development in GFA in 2018; and soon after, introduced for on-campus and online use.

The Role of GFA

Course development in the GFA plays an important role in ASU's math innovation (and other courses). The GFA provides a sandbox unavailable to any other university; what is learned in the GFA is migrated to on-campus and online courses. While MOOC's have been around for years, they have never been offered for credit globally. To do so requires:

- Extraordinary resources and talent from ASU's EdPlus to build the massive and open GFA courses for credit, maintaining our course design efforts at the frontier.
- The resources also provide opportunities for EdPlus to experiment with different designs that extend what can be accomplished in digital learning environments, such as "just-in-time tutoring".
- These courses make available massive amounts of detailed data in real time on an equally massive number of learners. The data analytics that can be performed for learning science seem almost unlimited.
 - ✓ In its first year, the GFA College Algebra course attracted more than 50,000 learner, of which about 10,000 proved to be engaged students and more than 500 completed the entire course, mastering more than 90% of the curriculum.
 - ✓ Cumulatively, the 50,000 learners were tested on more than 1.5 million math skills and GFA students mastered more than 500,000 skills, more than 1,500 new math skills learned each day.

The Role of Adaptive Learning for Access

Adaptive courseware also plays an important role in ASU's mission for access. The math innovation (and other courses) ongoing in the GFA will tackle some of the greatest barriers to success in higher education and or STEM majors. This is true globally as well as locally.

- GFA courses provide access to college level courses for students around the world who have no other access.
- Or students who need alternative access. For example, GFA courses are used for the “Earned Pathway” for admission to ASU. A number of potential students do not meet admissions requirement, including Starbucks employees. They can earn admission into ASU by passing some GFA courses.
- Additionally, ASU Prep Digital embeds personalized, adaptive technology in all of their mathematics courses for all of their students, expected to be in the tens of thousands. This non-linear, adaptive approach gives students agency in their math education. While mastering individualized objectives, students also collaborate with peers in weekly mathematics challenges and engage in live teaching sessions with their instructors.

Connected Courses

Another “next step” in the evolution of math education is “connected courses”. Discussions have begun to select developmental partners to build connected courses. The idea is simple; the technology complex.

- Success in many courses depends on pre-requisite knowledge brought forward from previous courses. This is most apparent in math classes and classes that depend on mathematical knowledge. The first calculus course for engineers depends on knowledge of pre-calculus. The engineering calculus classes that follow depend sequentially on the prior calculus classes.
- It does not stop there. Physics beyond general education requires proficiency in calculus. Thus Physics must also “connect to” calculus; and so forth.
- Often students stumble because they lack adequate recall of knowledge from prior classes. Connected courses solve this by remediating/refreshing content knowledge wherever and whenever the courseware detects the student needs refresher content from previous courses in various subjects – courses will “talk” to each other.
- The calculus courses for lower division business and engineering will be among the first for development.