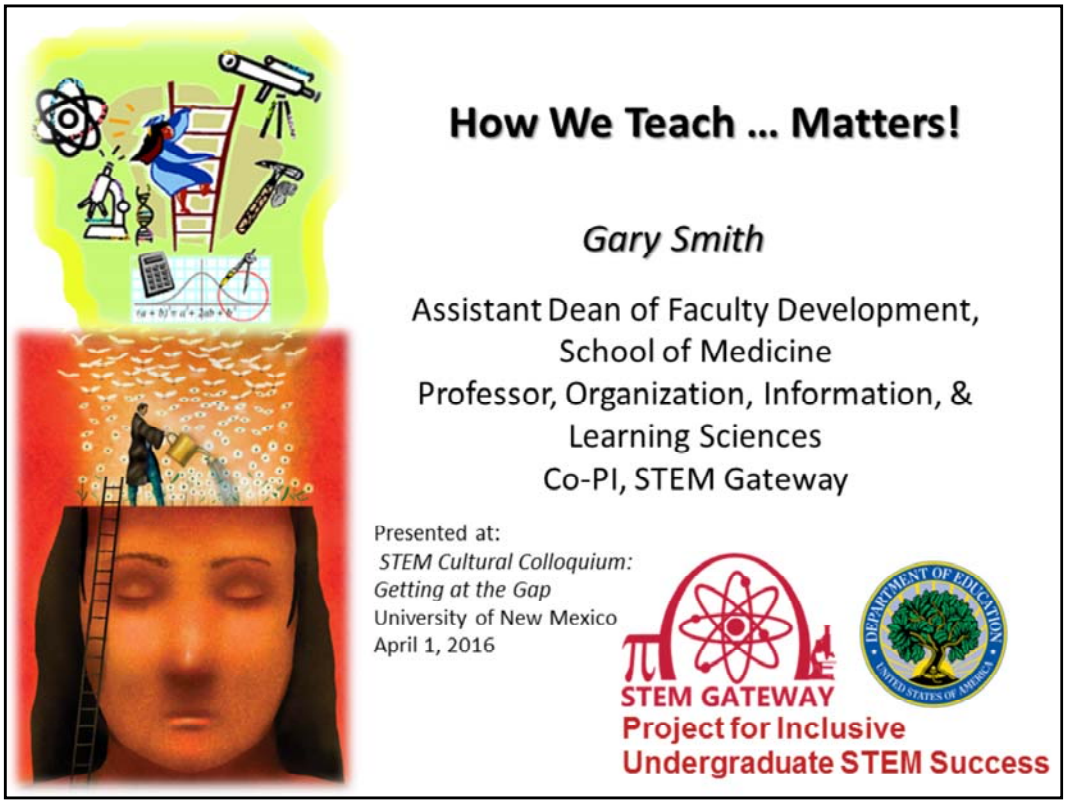
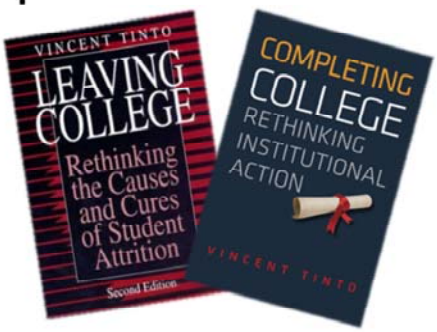


My title gives away my message: Of all the factors that affect the pipeline of STEM students and achievement gaps within the pipeline, I will argue that how we teach in the classroom and how we regard students during their coursework is most important.

Before building that argument, let me sort through these affiliations to establish where I'm coming from. I am in my 29th year at UNM and 28 of those years was spent as faculty in the Department of Earth and Planetary Sciences – I am an experienced STEM faculty member. For the last decade, I have also been a faculty developer; first directing the Office of Support for Effective Teaching on the main campus and more recently leading faculty development at the med school. I am also the author of the STEM Gateway grant, which has many components directed at improving the success of Hispanic and low-income students in the entry level courses that commonly derail the ambitions of aspiring math, natural science, and engineering students. These components are led by a variety of people and I took on responsibility for guiding the course-redesign component of the project. My perspective today, therefore, is framed by my experience as a STEM professor and as someone working with faculty to adopt evidence-based, inclusive pedagogies for student learning and success.

Raise your hand if you are a faculty member. My message is primarily for you … for faculty. I ask everyone to consider taking what you learn today to the STEM faculty who you know.

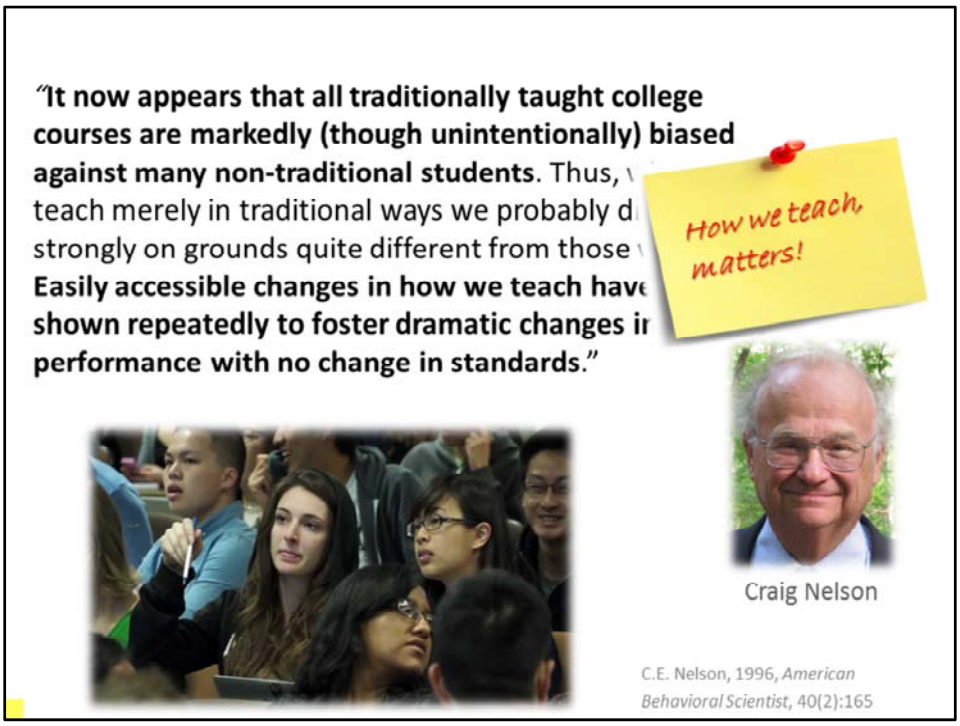
"… student success, however it is defined and measured, must have at its core **success in individual classes**. Though student success is indeed everyone's business, it is **the business of faculty in particular**."



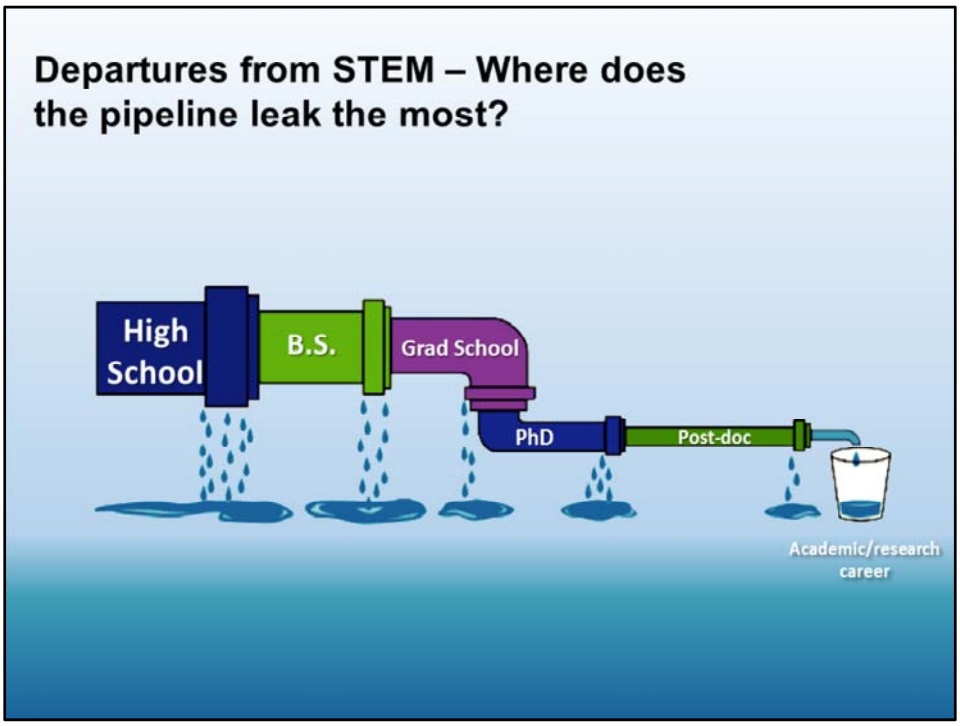
Vincent Tinto

Tinto, V., and Pusser, B., 2006, *Moving from theory to action: Building a model of institutional action for student success*

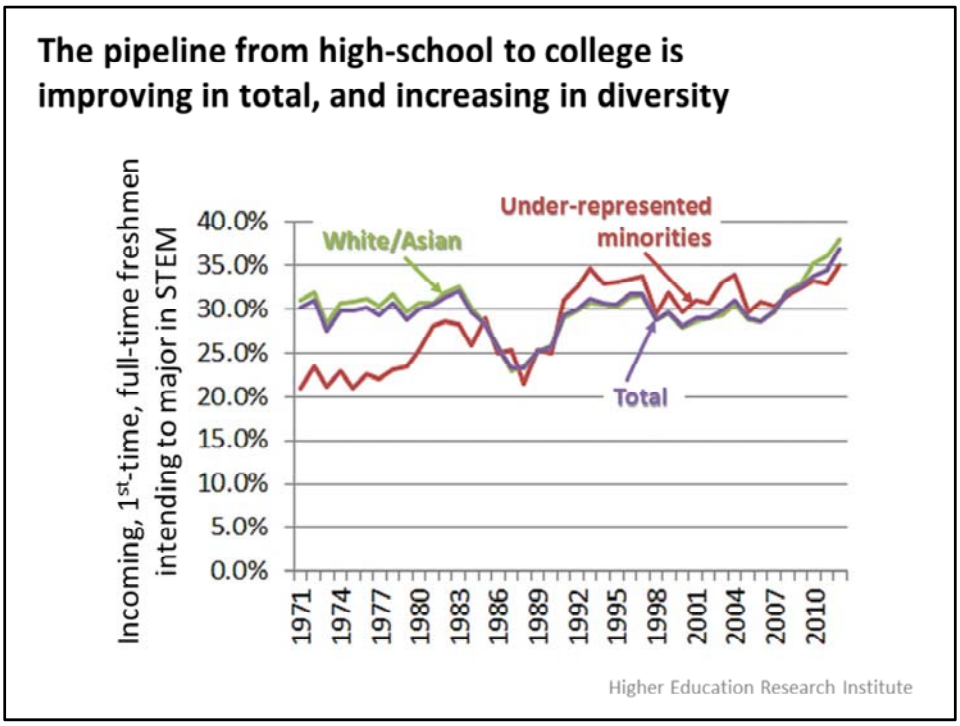
My primary thoughts for today are motivated by the writings of two higher education scholars. Vincent Tinto is arguably the leading researcher on student retention and graduation. A few years back he wrote: [ ]. And let's pay particular attention to what I highlighted. Success occurs because of the learning achievement in courses and this makes student success the particular business of faculty.



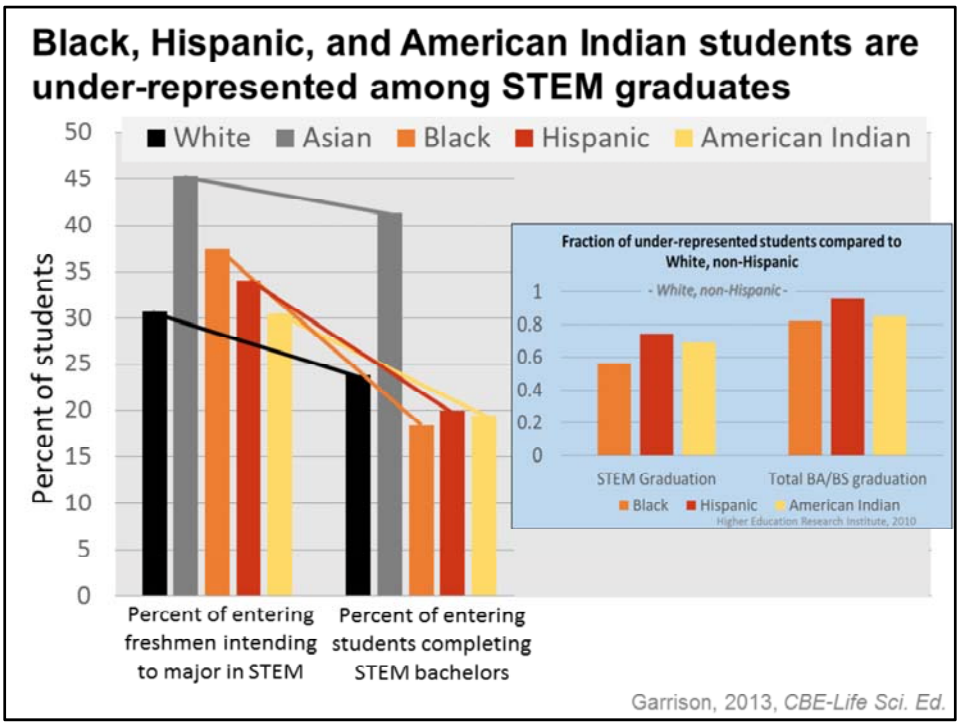
Craig Nelson is an accomplished evolutionary biologist and recognized leader in the scholarship of teaching and learning. Twenty years ago he published words that remain very true, today: [ ]. If this surprises you, and perhaps it doesn't for those in this audience, then I will show you evidence for what Craig is saying: Both how the way we teach does bias against some students and how changes in teaching can alleviate these gaps. I also want to hone in on what Nelson means by intended and unintended discrimination. He is using "discrimination" to refer to separation. We do, as teachers, intend to separate students using grades that indicate learning. That learning achievement should, however, be related to capacity and competency to learn and not determined by knowledge of the norms of higher education.



The leaky pipeline metaphor is commonly used to represent the attrition of STEM-aspiring youth between high school and eventual academic and research careers. The metaphor typically shows the leaks as a plumber would draw them, as occurring at the joints between pipes. Therefore, if you are a faculty member responsible for learners in the undergraduate part of the pipeline awarding BS degrees, you tend to see the problem of STEM attrition as related to losses between high school and college matriculation. But, the data suggest otherwise.



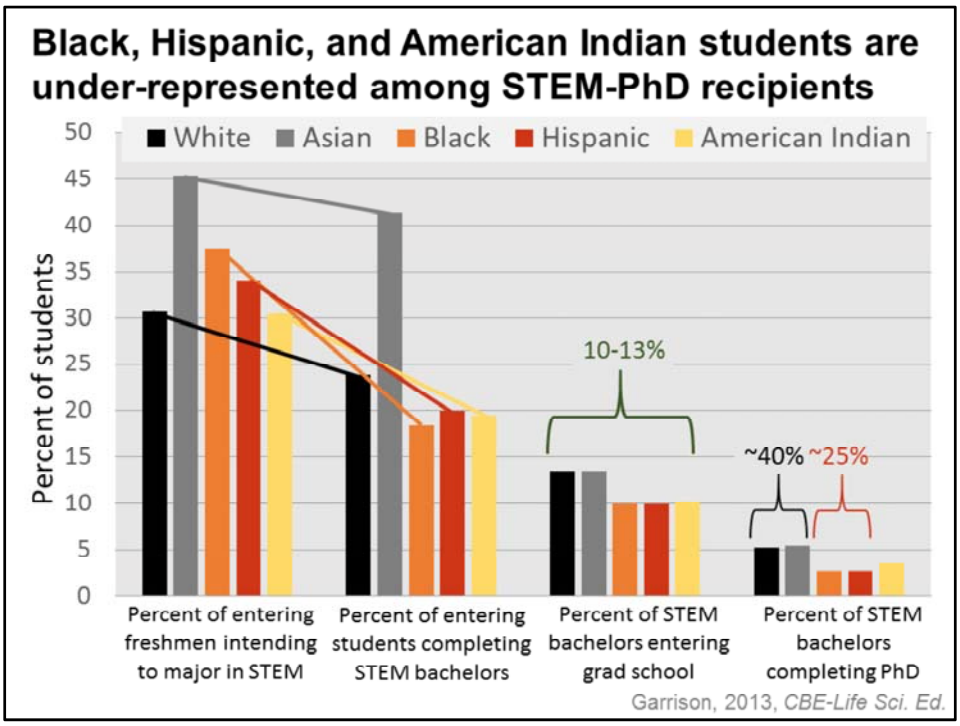
The number of freshman entering college with aspirations to major in STEM started increasing about a decade ag. And, notably, the ethnic and racial discrepancies that were so prominent 40 years ago have essentially disappeared.



Shown another way, the percentage of Black, Hispanic, and Native American students entering college as aspiring STEM majors is actually as high or higher than for Anglos.

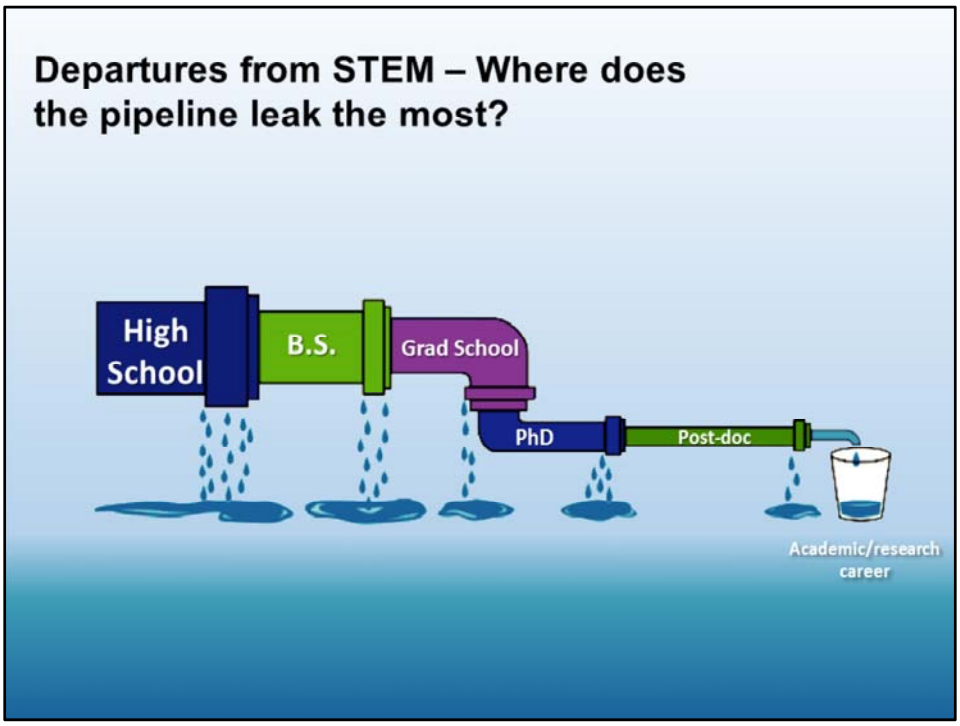
But, looks what happens by graduation time. There is similar, relatively low attrition among Anglo and Asian students, and much steeper declines among the traditionally underrepresented groups. Now you might say, "But, Gary, these racial and ethnic groups have overall lower graduation rates, so this is not symptomatic of issues with STEM. But, I disagree …

As a fraction of Anglo graduation, STEM graduation rates among these underrepresented groups is significantly lower than for college graduates in general. It **is** a problem with STEM.

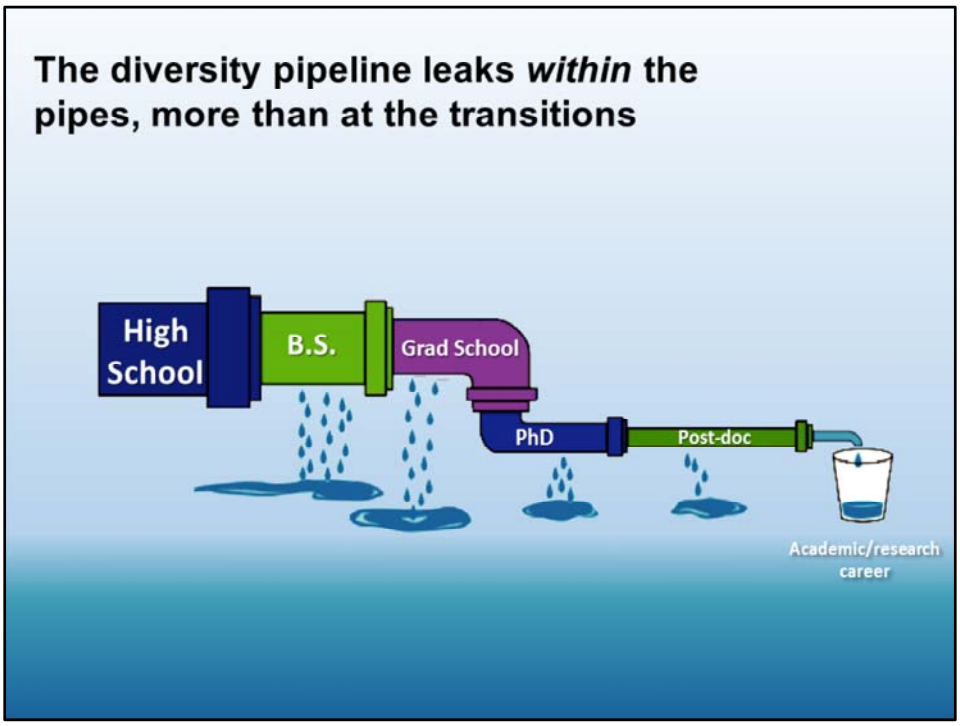


Let's go to the next stage – graduate school. Not every undergraduate needs to pursue graduate school in order to achieve life and career goals. And, I'm not too impressed with the difference between whether 1 in 8 or 1 in 10 students from different groups go on to grad school.

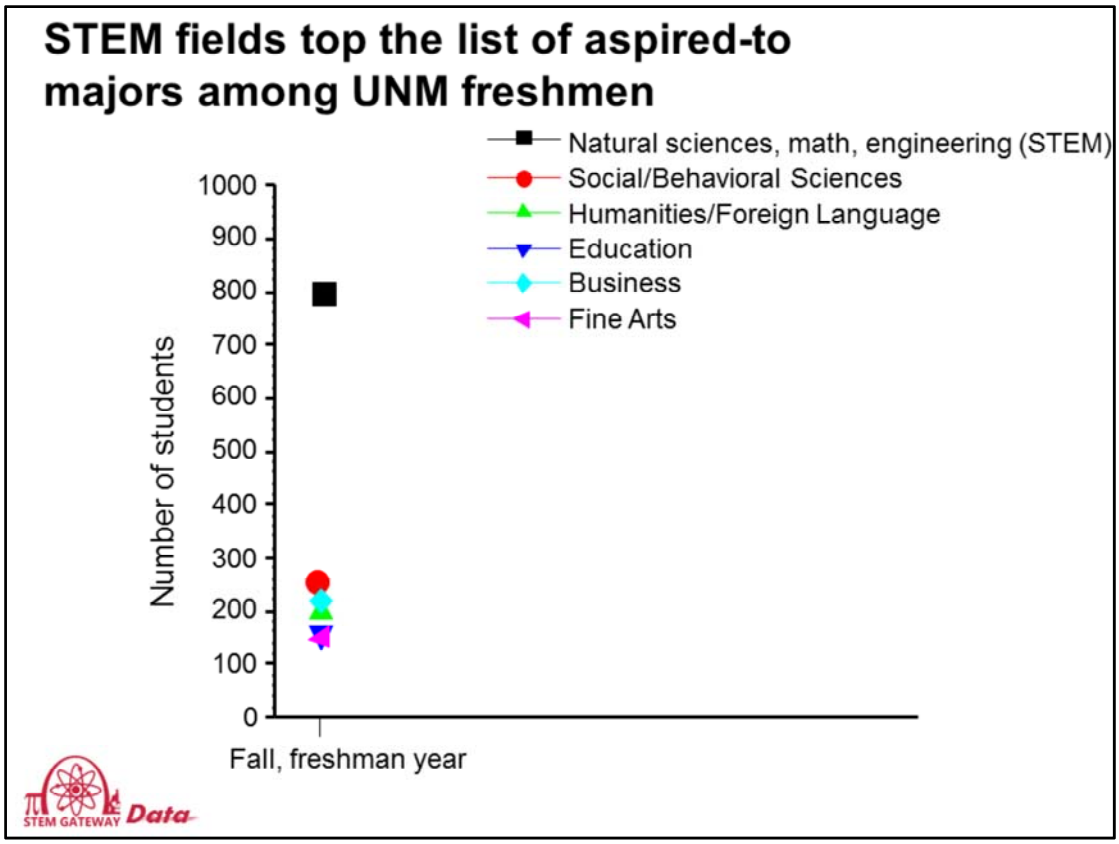
But, what is striking is that while 40% of those White and Asian graduate students will obtain PhDs, only one quarter of the Hispanic and African American students will. Why?



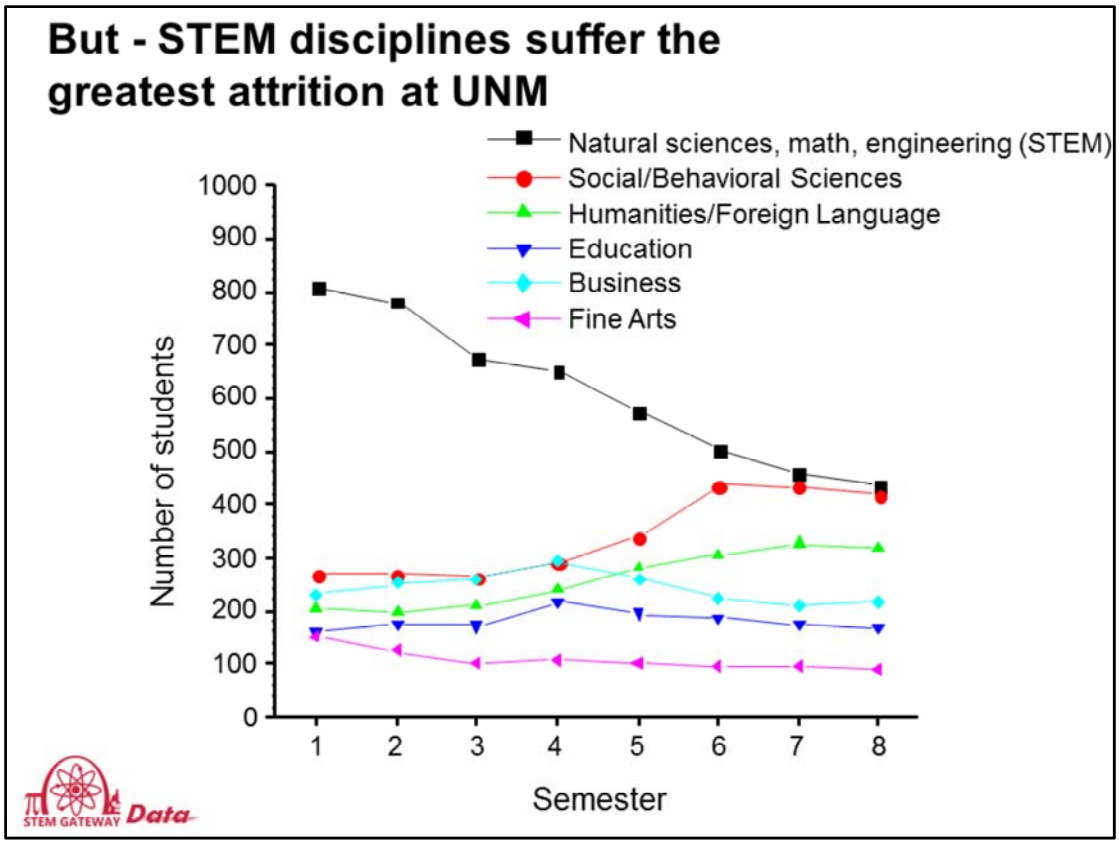
I argue that we draw the pipeline incorrectly



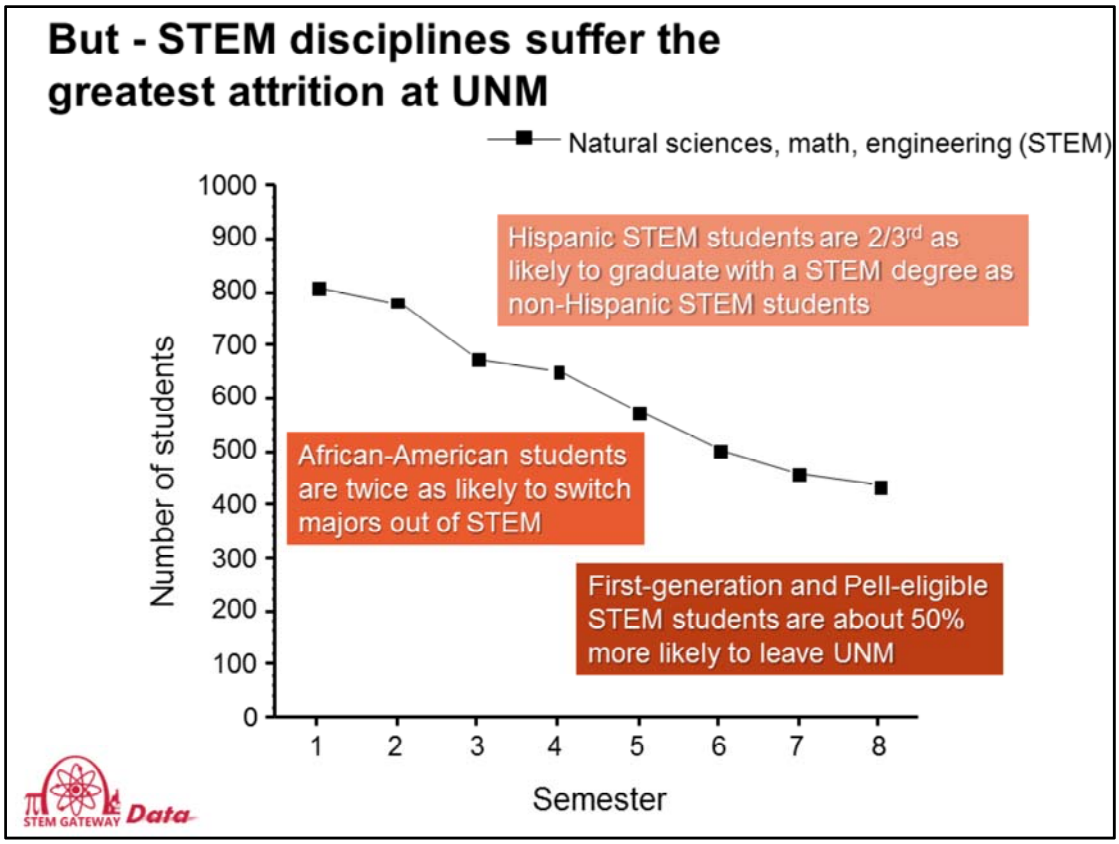
The diversity pipeline leaks most badly within the pipes, not at the transitions. And those of us responsible for student movement through our responsible pipe need to patch those holes that surround us.



The national trends are reflected by UNM students. When I wrote the STEM Gateway proposal, I looked at data from several incoming freshmen cohorts. What I discovered is that the pipeline bringing STEM-aspiring students to UNM is strong. With freshmen interest in STEM far exceeding known interests in other disciplines.

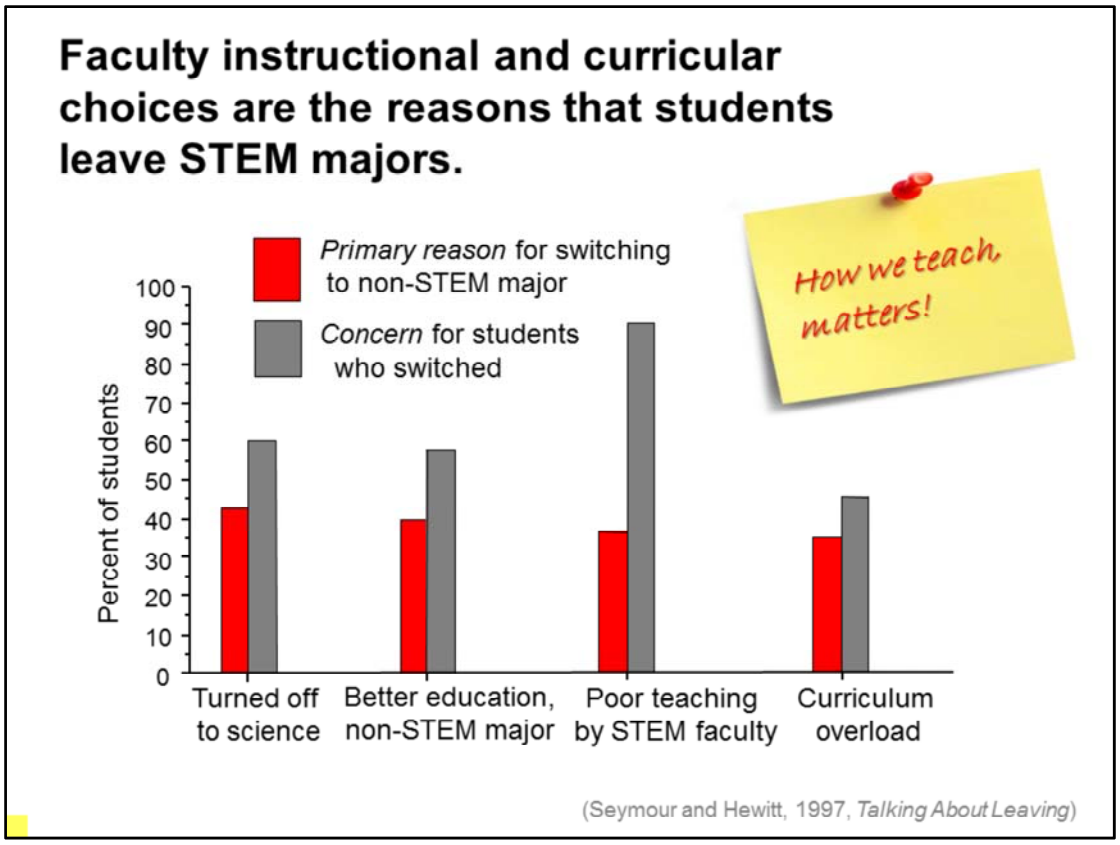


But, watch what happens over the next 4 years.

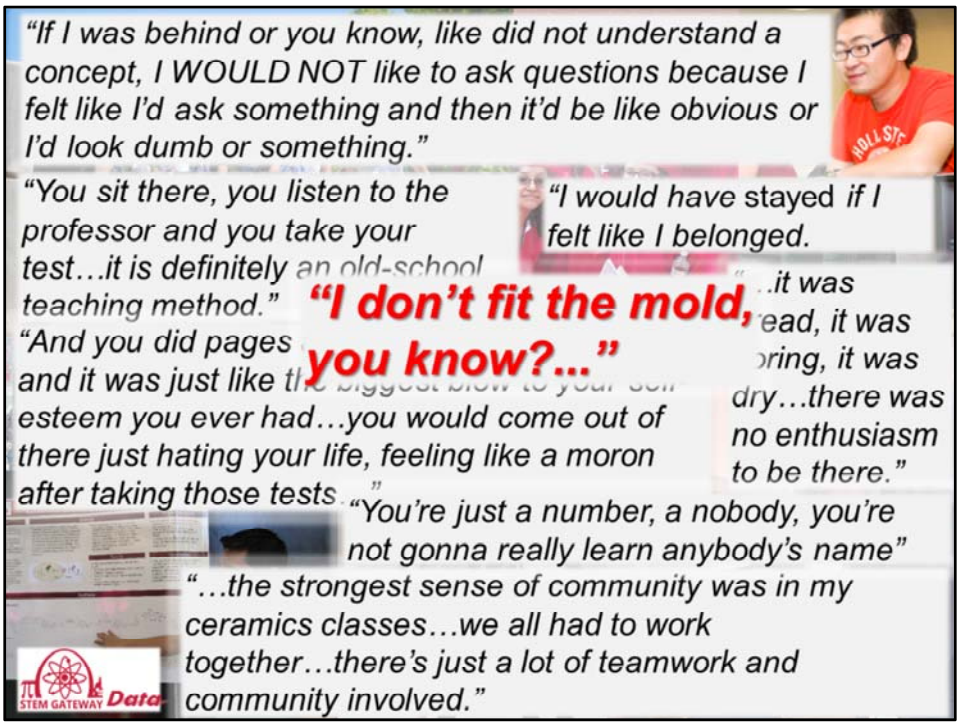


And – these losses are not even for all groups of students. STEM Gateway data analysis shows that: [ ]

So, why do students leave the aspired-to degree programs?

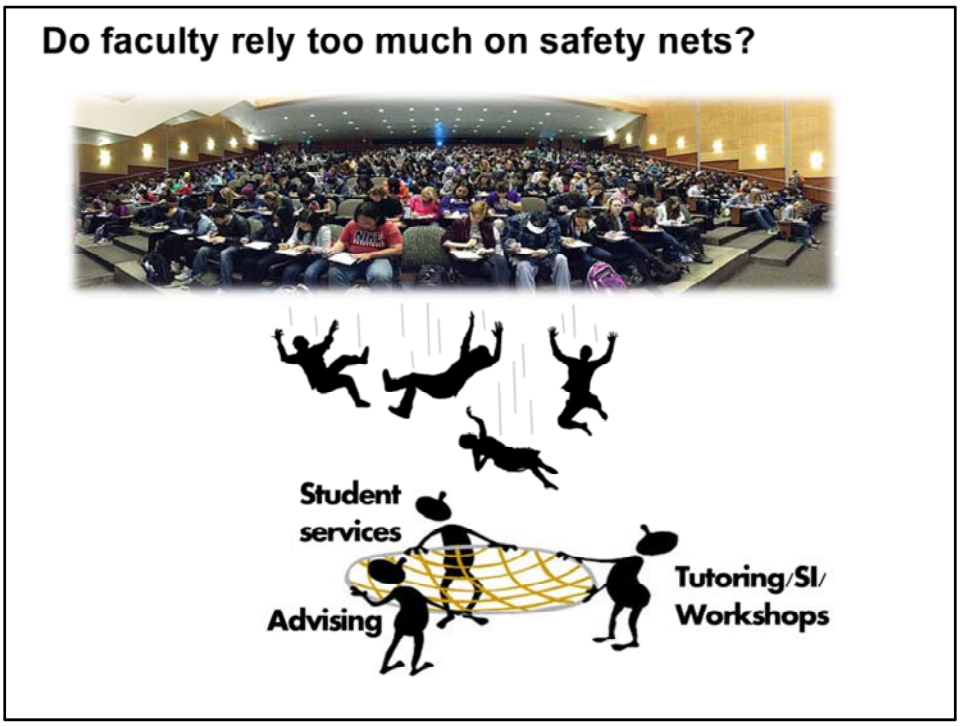


Seymour and Hewitt explored this question in a mixed-methods study of students across America. From their interviews, they summarized both the primary reasons for switching out of STEM and issues that concerned them, even if not triggering departure. Yes, the curriculum is challenging: Lots of lab courses and a rigid prerequisite structure that includes many courses outside the major department. But look at what mattered more: Poor teaching, especially compared to what was discovered in courses in other fields. And ---- how can it be that a student arrives in college to pursue science or engineering and then gets turned off to it? *How we teach, matters*. Seymour and Hewitt provided extensive analysis and many examples of the problems in the words of the students. Many people saw this study as the necessary trigger to change STEM education in American universities, but arguably, nothing has changed in the intervening 20 years.



The issues clearly persist at UNM, especially for students of color. STEM Gateway researcher Ashley Yoder interviewed STEM students of color at UNM who switched out of STEM majors or departed UNM altogether. Here are the words of some of those students … remarkably similar to the subjects who Seymour and Hewitt interviewed across the country in the 1990s. I'll let you read them.

Keep this last one in mind because we will return to it --- I don't fit the mold, you know?

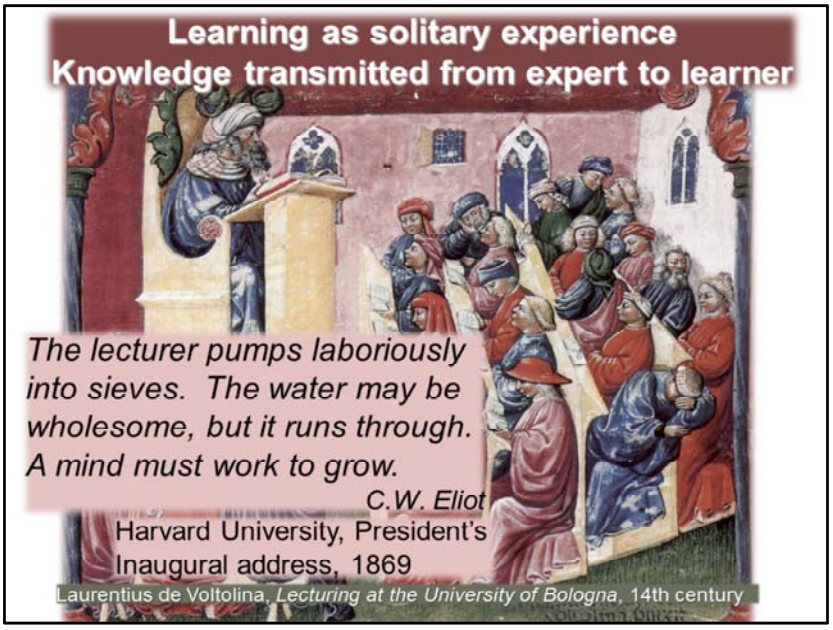


So, what do we do when students are struggling in class? Based on nearly three decades of talking to STEM faculty at UNM I am very concerned that many don't feel that it is their problem to address. Especially when there are safety nets. Now, don't get me wrong. These academic-support services are essential. But, do we seriously ask why it is that the students fell out of the classroom boat to begin with? And, given the well-known demands of jobs and families in the lives of our students, will they all be able to fully take advantage of these services? Especially for those who avoid the stigma of needing help?

"Student success, however it is defined and measured, must have at its core success in individual classes."

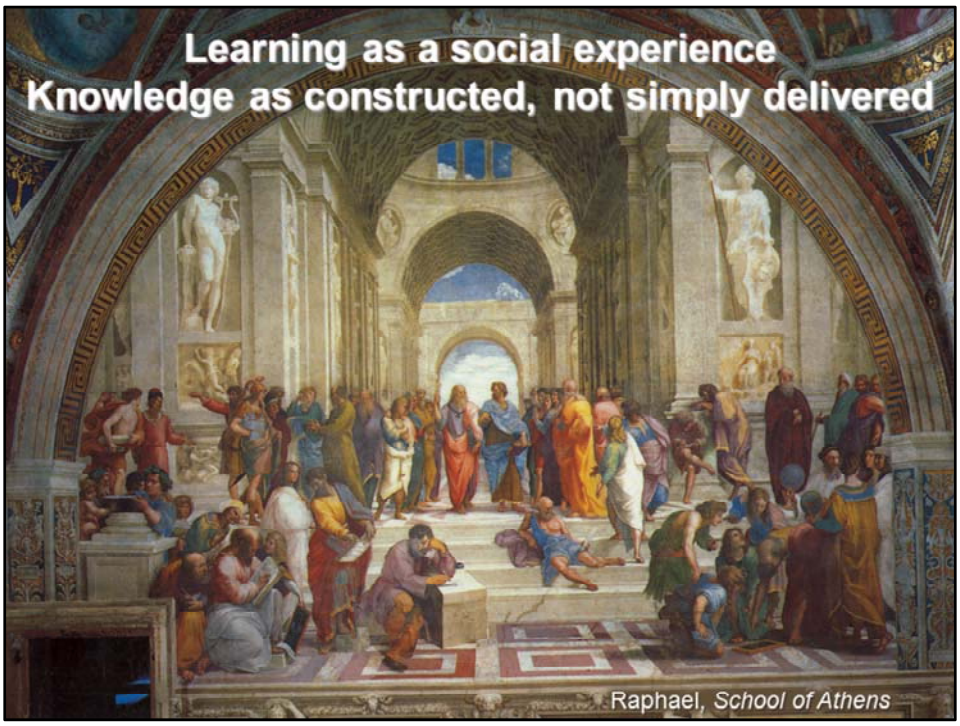
"Easily accessible changes in how we teach have been shown repeatedly to foster dramatic changes in student performance with no change in standards."

Let's come back to Tinto and Nelson for reminders. The success that matters for progress toward degree and maintenance of financial aid along that route is the measured learning achievement in classes and we know how to improve that learning without lowering the bar. How we teach, matters! **So what are these changes that Nelson refers to?**



Fundamentally, modern universities continue a didactic tradition from Europe's oldest college of knowledge from expert to an individualistic learner. And, notice the inattentive, and even s picture. Lack of attention to learning in lectures is not, as some would say, a problem of "tod of an approach to learning that is contrary to everything we know about motivation to learn a process itself.

Chemist C.W. Eliot captured the problem now well known from learning science: [ ] Facu amounts of time making great lectures and wonderful PowerPoints. The content is valuable. become part of the memory of the learner. Why? Because the mind must work to grow --- ir be processed in working memory in the frontal lobe along with existing knowledge in order to retrievable knowledge. And when was this very cogent metaphor for problems of university l



What's the alternative? The human brain evolved for constructing knowledge through learning with others. The Greeks had it down, long before the first European universities. **But what does this look like in the modern university and does it improve student learning and diminish achievement gaps? Yes --- let me show you through two examples.**

Case Study:
University of Washington, Introductory Biology

Scott Freeman

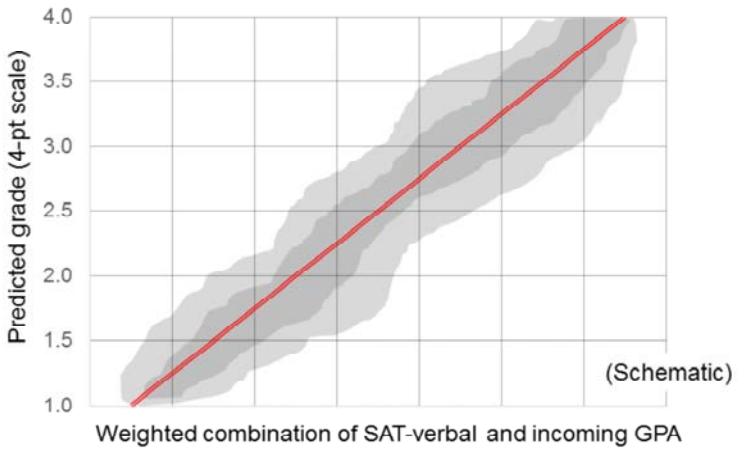
Educational Opportunity Program (EOP) students are from educationally or economically disadvantaged backgrounds; most are first generation to college; 76% are from under-represented minorities

Our first case study is introductory biology at the University of Washington, and particularly the teaching and research of Dr. Scott Freeman, shown here in a lecture hall with his students.

Of particular note, his classes include a significant number of students who have joined UWs Educational Opportunity Program. These students are identified as having characteristics that put them at a disadvantage for succeeding at UW. We will examine the impact of course redesign on these EOP students.

Student preparation is a predictor of course grade

Case Study – University of Washington, Introductory Biology

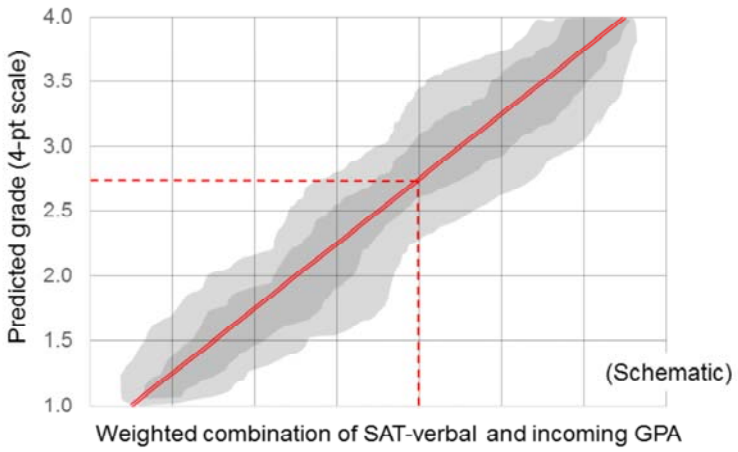


Haak et al., 2011, Increased Structure and active learning reduce the achievement gap in introductory biology, *Science*, 332 (6034): 1213

First- some context. Freeman and his colleagues noted, using data over a number of years, that the grade earned by a biology student could be reasonably well predicted if you knew their incoming GPA and score on the verbal section of the SAT admissions test

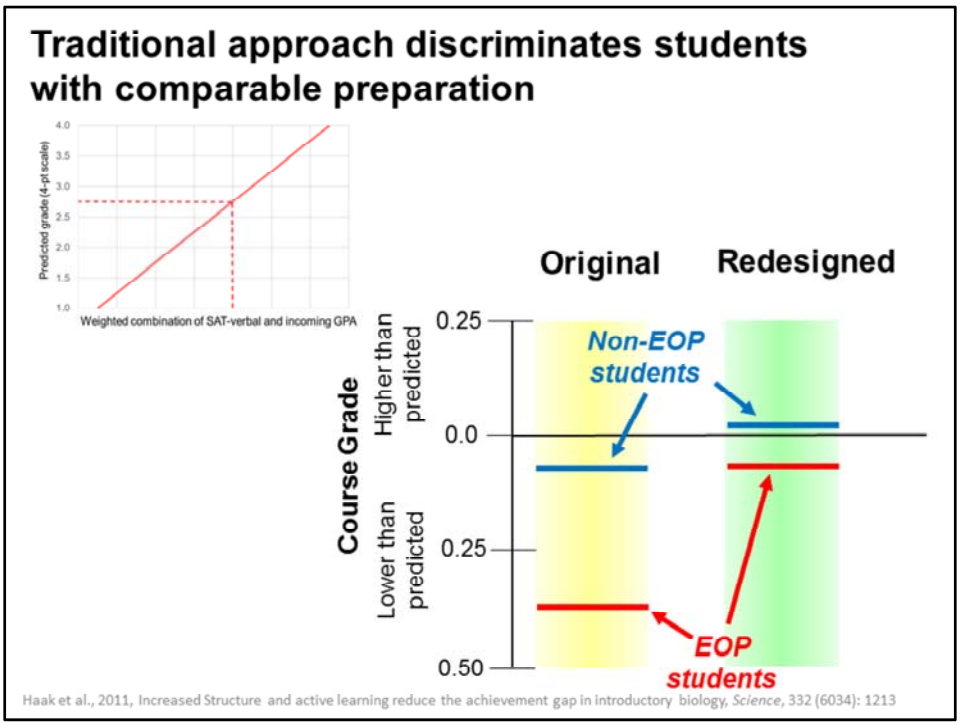
Student preparation is a predictor of course grade

Case Study – University of Washington, Introductory Biology



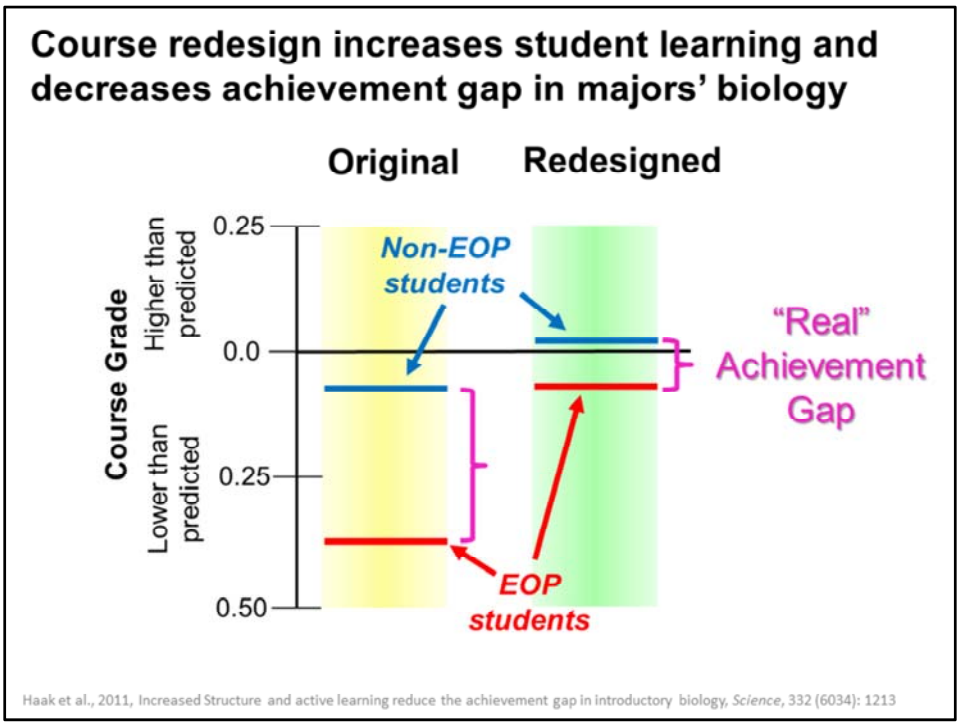
Haak et al., 2011, Increased Structure and active learning reduce the achievement gap in introductory biology, *Science*, 332 (6034): 1213

As shown by this example.

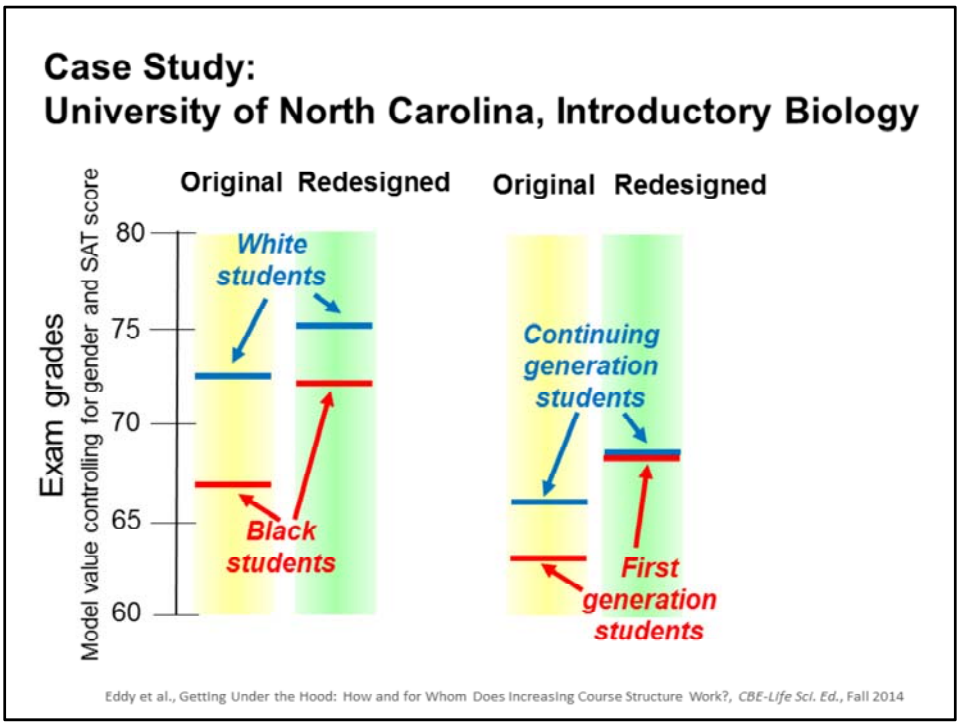


Freeman looked at the data for his rigorously taught sections and found that most students obtained grades slightly lower than predicted but still substantially higher than for the EOP students. The average gap is roughly one-third of a GPA point, or one fractional letter grade.

But when he redesigned his course, the grades of both groups improved and the gap decreased.

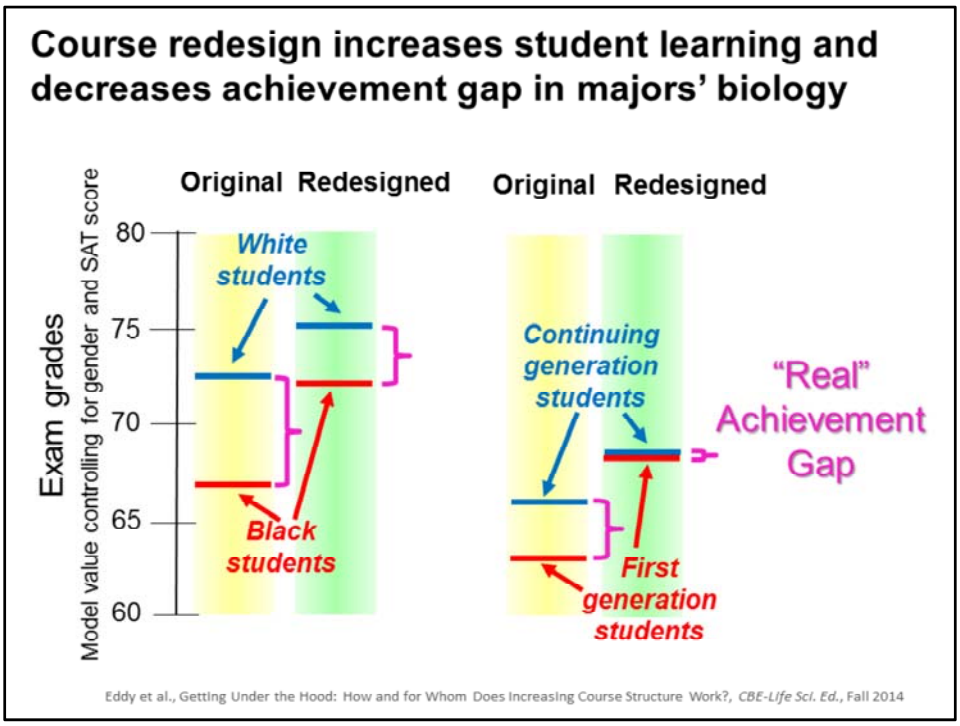


Let me emphasize that --- the achievement gap decreased. I call this the real gap because it is not related to disparities in opportunities for educational preparation known to be correlated with socioeconomic status … BECAUSE, remember that we aren't looking at the actual grade but rather the predicted grade based on other measures of preparation for the course. To use Nelson's words, Freeman's course redesign decreased the unintentional discrimination of equally qualified learners.

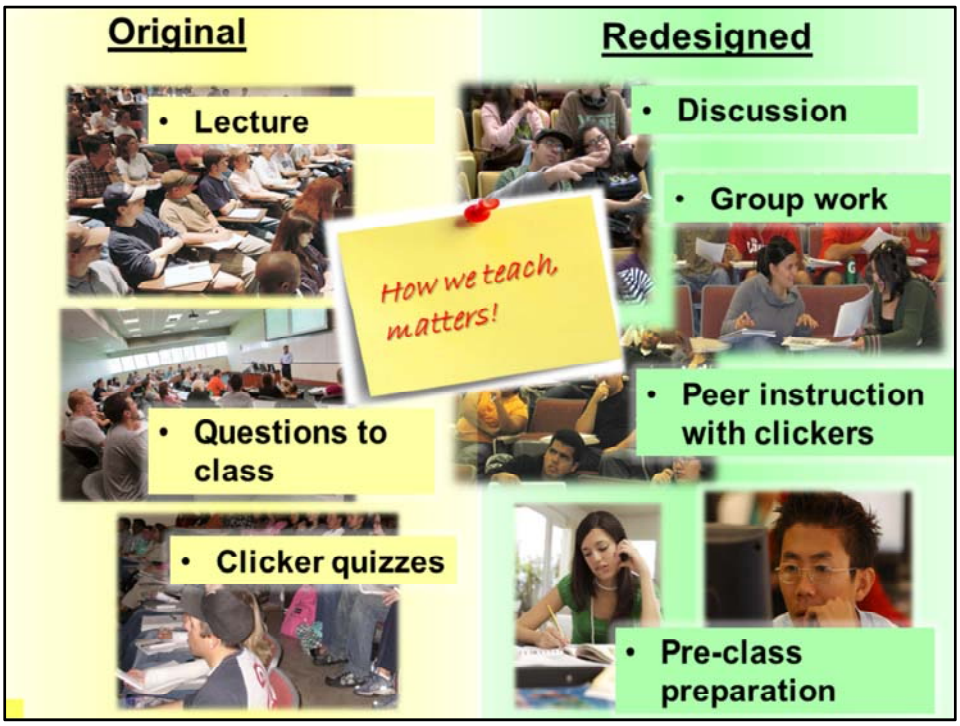


Let's look at another example: The consequence of biology redesign at the University of North Carolina. Here you see gaps in exam grades as adjusted for gender and SAT score, as a measure of preparation.

In the redesigned course, grades improved…

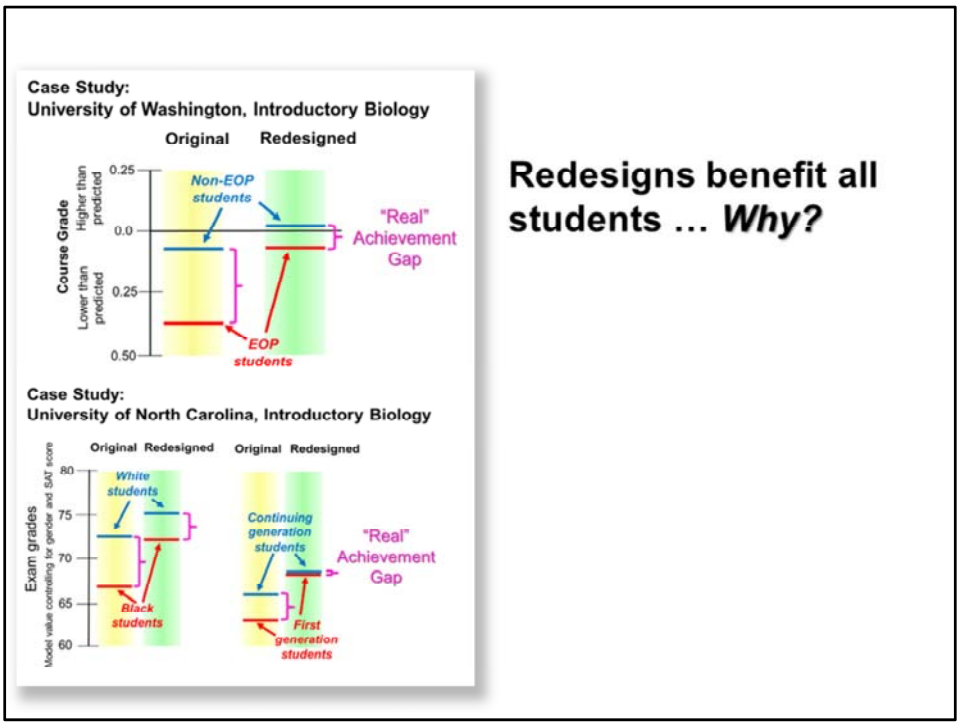


… and the real achievement gap decreased. **So --- what's different about the original and redesigned courses?**



The original course designs were pretty traditional didactics… the 21st century version of the University of Bologna with a strong emphasis on classroom lecture, questions thrown out into the void for possible answer by a few students, and quizzing with audience response systems.

The redesigned courses would look a bit familiar to the ancient Greeks --- lots of student discussion and problem solving in small groups. Using clickers not for quizzing but following a well-researched learning model called peer instruction. And, with students held accountable for some level of pre-class preparation for these learning activities. In essence, a model that has been popularized recently as flipped learning because of it contrast with traditional instruction. *How we teach, matters.*



But… let's go back and take note from these two case studies that the redesigns benefited all students, not just those experiencing unintentional discrimination. No harm was done to the students who performed well in the traditionally taught courses and they also experienced overall higher grades. Why? Because the instructional strategies used in the redesigned courses match the abundant evidence from cognitive psychology and neuropsychology for how learning actually works in the human brain regardless of demographic characterizations. Time does not permit me to illustrate these strong research-to-practice linkages, **so I'll simply share the conclusion as a stated by a UNM student**.

In the words of a UNM student, speaking to teachers:

- UNM student panelist, "Improving Native American Student Success"

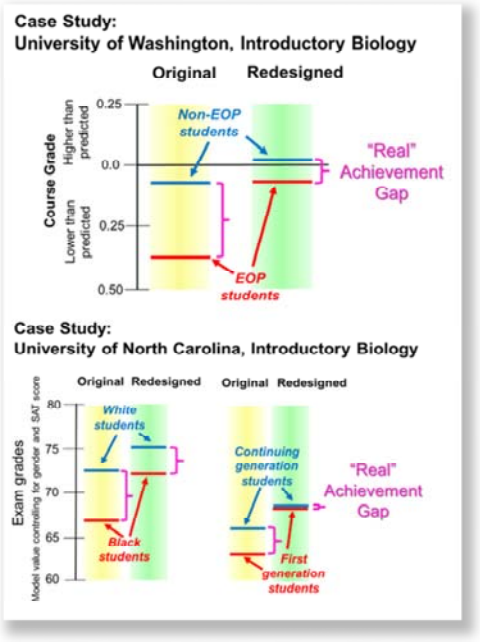
"Don't re-teach yourself. Standing at the front of the room talking and writing on the board is you re-enforcing what *you* know. *Engage* your students… we need to *work* with the material, *talk* about it, *think* about it, *not listen to you* all of the time."

"It is the one who does the work who does the learning"

Terry Doyle, 2008, *Helping students learn in a learner-centered environment*

A few years ago there was a panel discussion upstairs on the challenges of Native American student success at UNM. At the end of that session, a senior Dine student looked out at an audience of mostly faculty and said this: [ ]

She captured the essence of what cognitive psychology, neuropsychology, and learning science research has been saying for decades, and what Eliot said in his 1869 address at Harvard – the mind must work for learning to occur. Information must be manipulated in working memory in order for encoding of retrievable knowledge.



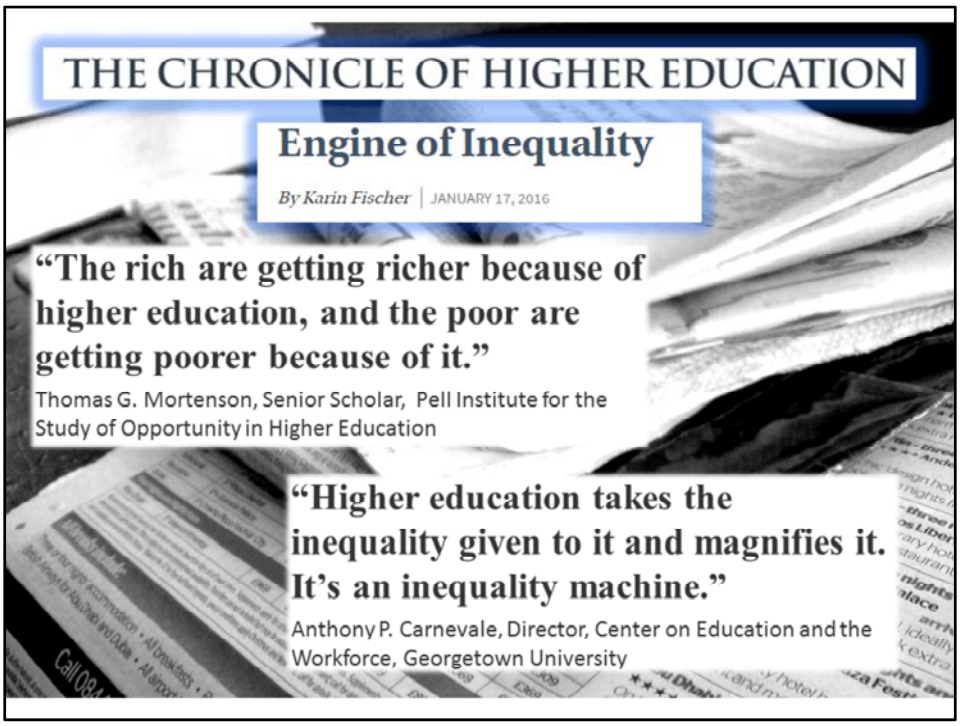
So… why did the original course designs "discriminate strongly on grounds quite different from those we intend?"

(Craig Nelson)

"I don't fit the mold, you know?..." *(UNM Student who departed STEM)*

Back, again to the results from Washington and North Carolina, we can ask – Why did …

The answer rests in the memorable comment by the UNM student: [ ]

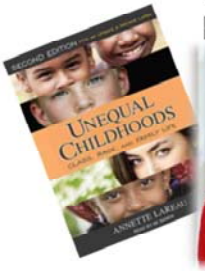


Perhaps some of you saw this story, which is part of an ongoing series in the Chronicle of Higher Ed. Despite what we hear from the White House and from the presidential campaigns, universities *are not* the engine of social mobility that they purport to be. The words of these nationally respected researchers cut to the bone. How can this be? What are the implications for teaching?

I'm going to revert to my geological academic roots and use the Grand Canyon as a metaphor for the chasm that exists between the culture of higher education and the student that don't draw from social and cultural capital to have the cultural knowledge to navigate higher ed. Cultural knowledge includes the facts, information, skills, and familiarity with social processes and particularly knowledge of how institutions work. It is different from academic knowledge and different from non-cognitive knowledge. It's about the formal and informal rules of the institution that permit successful navigation.

Middle-class young adults compared to working class and poor youths have more knowledge of the "rules of the game"

- How to drop a class
- What grades are necessary for med school
- How to secure an internship
- How to secure a job after college
- Sense of entitlement to ask for help from teachers
- Getting preferences and needs accommodated by the institutions



Annette Lareau

Lareau, 2015, Cultural knowledge and social inequality. *American Sociological Review*, 80(1): 1 –27

Annette Lareau at the University of Pennsylvania collected longitudinal data for 20 years from families across a wide socioeconomic spectrum. When it came to cultural knowledge of college, the middle-class students whose parents precede them to college and/or had the benefit of excellent college prep schools brought cultural knowledge of universities… they knew the rules of the game that working class and poor youths did not have access to. Including greater likelihood of accommodations and needs.

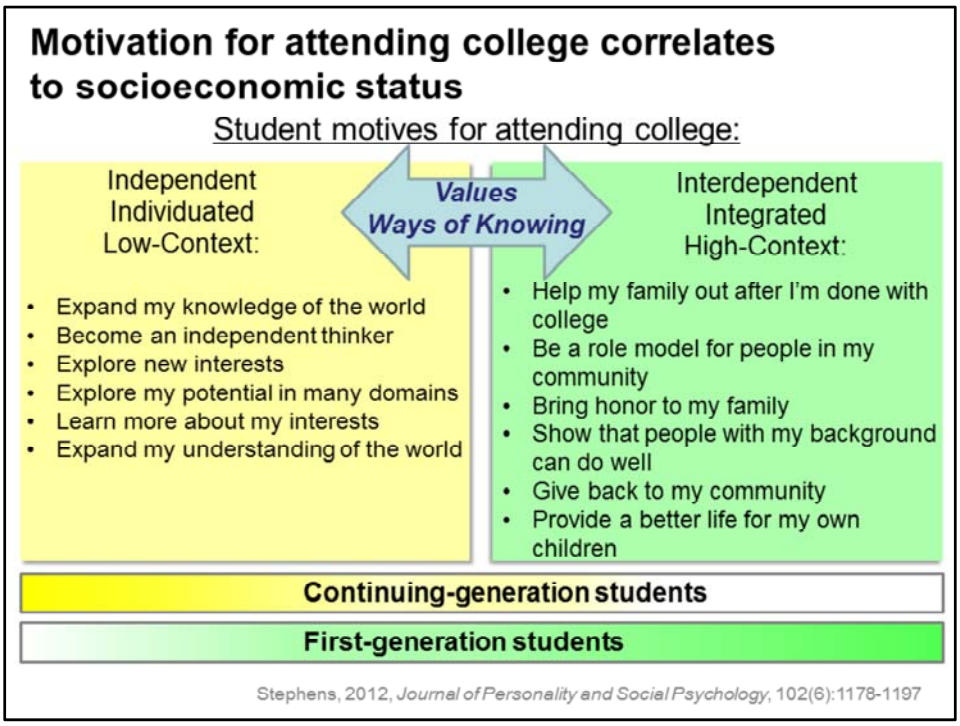
***Cultural mismatch theory* explains the chasm between universities and the growing numbers of first-generation students**

"The culture of higher education itself plays a pivotal role to … produce social class inequalities among students because they are built and organized according to taken for granted, middle- and upper-class cultural norms, unwritten codes, or 'rules of the game.'"

Stephens, 2012, *Journal of Personality and Social Psychology*, 102(6): 1178-1197

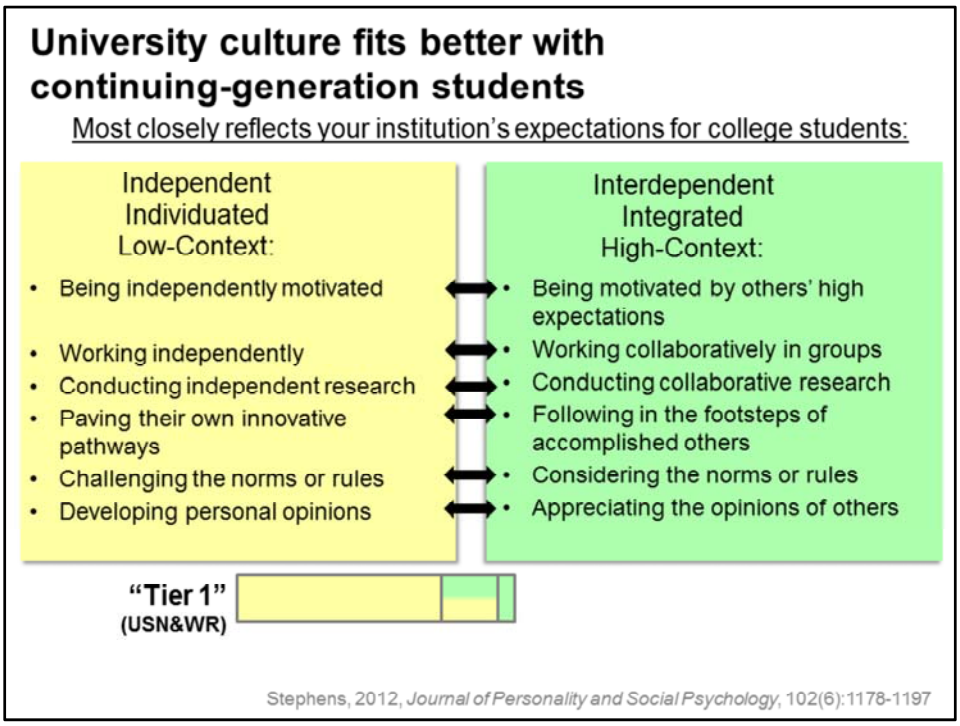
Nicole Stephens

I encourage you to read the fascinating mixed-methods studies by Nicole Stephens at Northwestern; work that supports her cultural mismatch theory for explaining the chasm. [ ] Again, the rules of the game, the same phrase used by Annette Lareau, becomes the characterization.

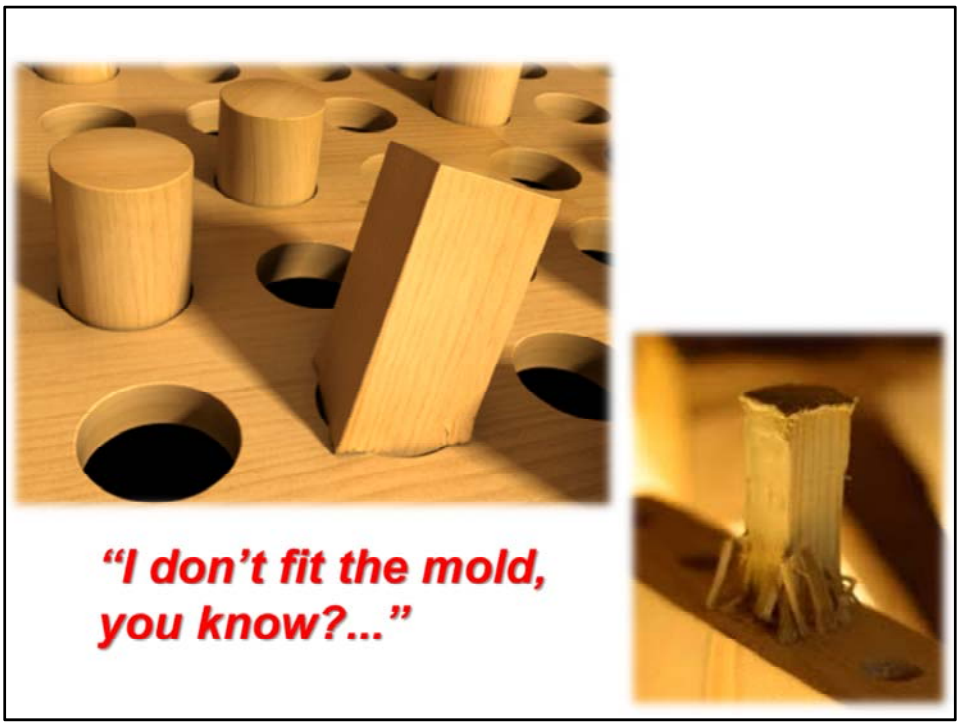


Let me show you one aspect of her work. She identifies two end-member descriptions of values and ways of knowing: independent and interdependent. For those of you familiar with the work of UNM faculty in the sociology of education, these terms are analogous to what Roberto Ibarra in Sociology refers to as low-context and high-context learning; and to what Alicia Chavez in Educational Leadership describes as individuated versus integrated epistemologies. Stephens developed a survey around these concepts that elicited students' motives for attending college …. Here are example survey items. Continuing-generation students - those for whom at least one parent completed a college degree – were strongly responsive to the independent side. First generation students were a bit more broad based, what Roberto Ibarra would refer to as multicontextual, but statistically significantly different and anchored more on the interdependent side.

First generation were 46% low income, 40% white/Asian
Continuing generation were 7% low income, 61% white/Asian

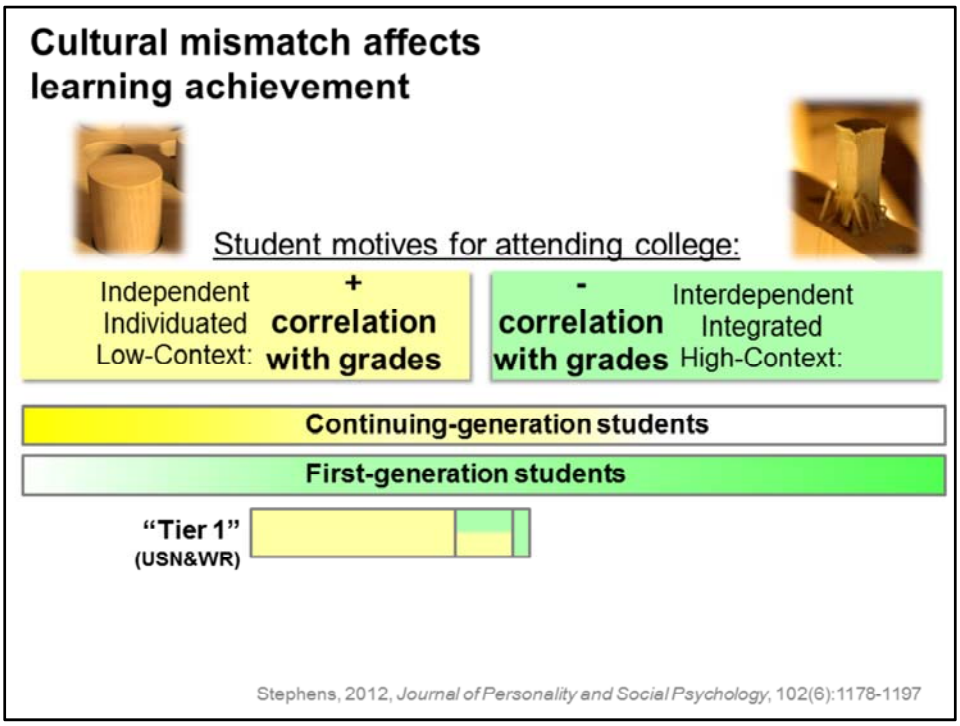


How do these distinct motives and values related to learning match up against the expectations of higher education? Stephens developed a survey that included opposing pairs of expectation statements and asked administrators to indicate the degree of match to their institution. From USN&WR tier 1 schools – the top 50 national universities and 25 liberal arts colleges – there was a strong skew toward independent, with some schools that were mixed and very few respondents supporting interdependent.

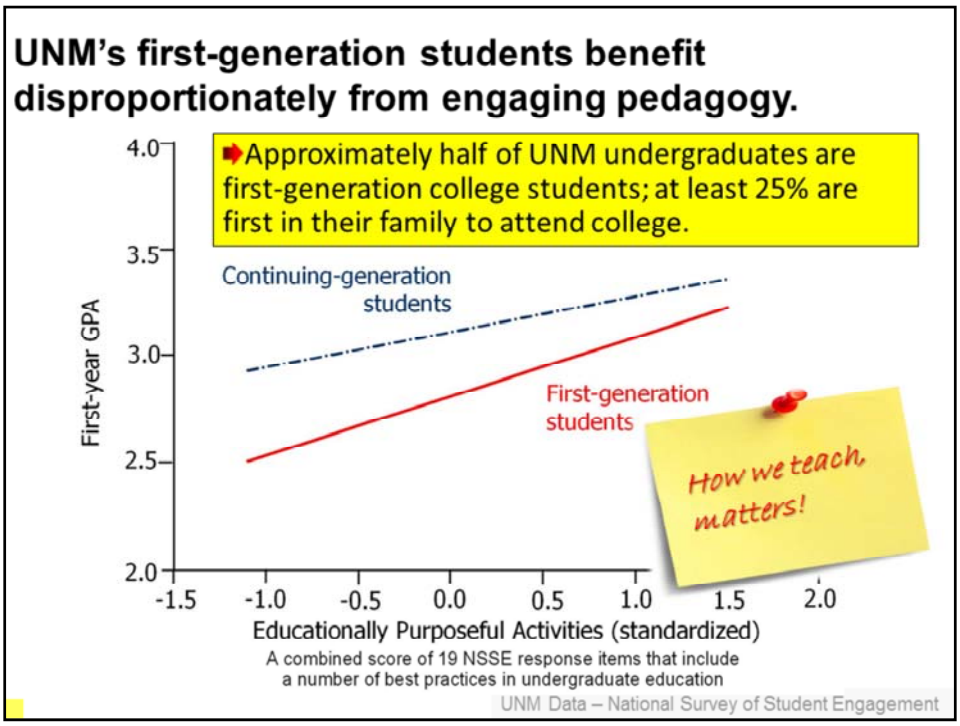


Here in lies the cultural mismatch. Students are a combination of round and square pegs but the expectations of the institutions and their faculty favor continuing generation students.

The square pegs either fall off the table or they are fitted into round holes with damage …. I don't fit the mold, you know?



And, in the next step of Stephens research we can see the damage from the mismatch. Grade achievement in the first two years correlates positively with the students' motives toward the independent values favored by the institution. And grades correlate negatively with the interdependent context favored by first-generation students.



This distinction based on parental education is important at UNM. Several years ago several of us analyzed UNM's data from the National Survey of Student Engagement and found that educational activities determined much of the grade-achievement gap between continuing and first-generation students. I don't have time to explain this measure of 19 items on the NSSE survey, but they are affected by instructor choices in teaching.

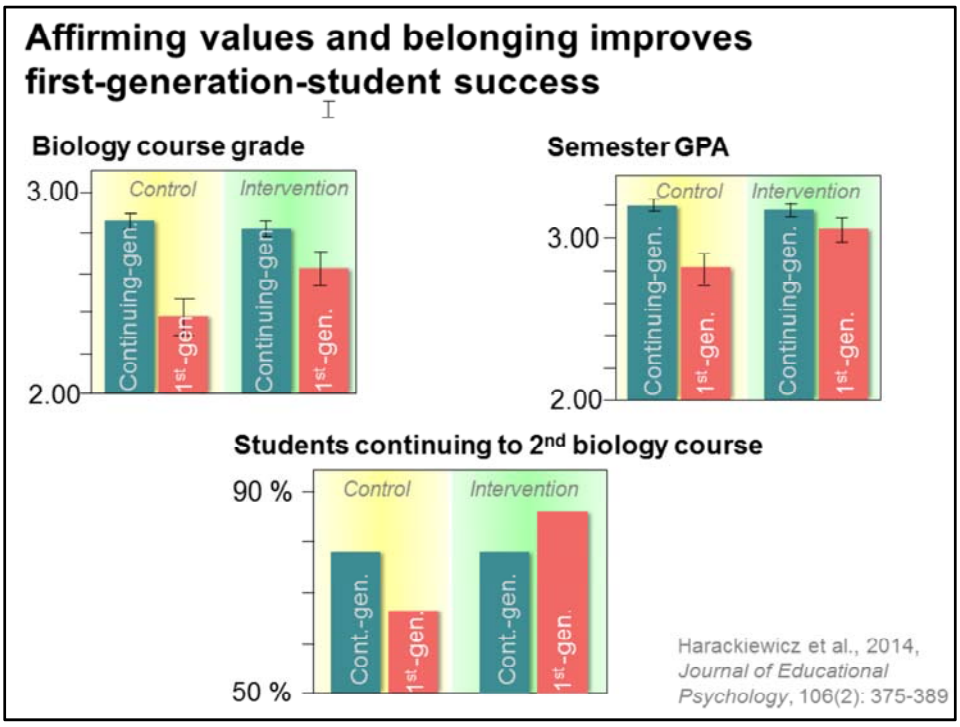
How we teach matters.

So, are there ways to reduce the damage from cultural mismatch? Let's take a look at an example.

Case Study:
University of Wisconsin, Introductory Biology

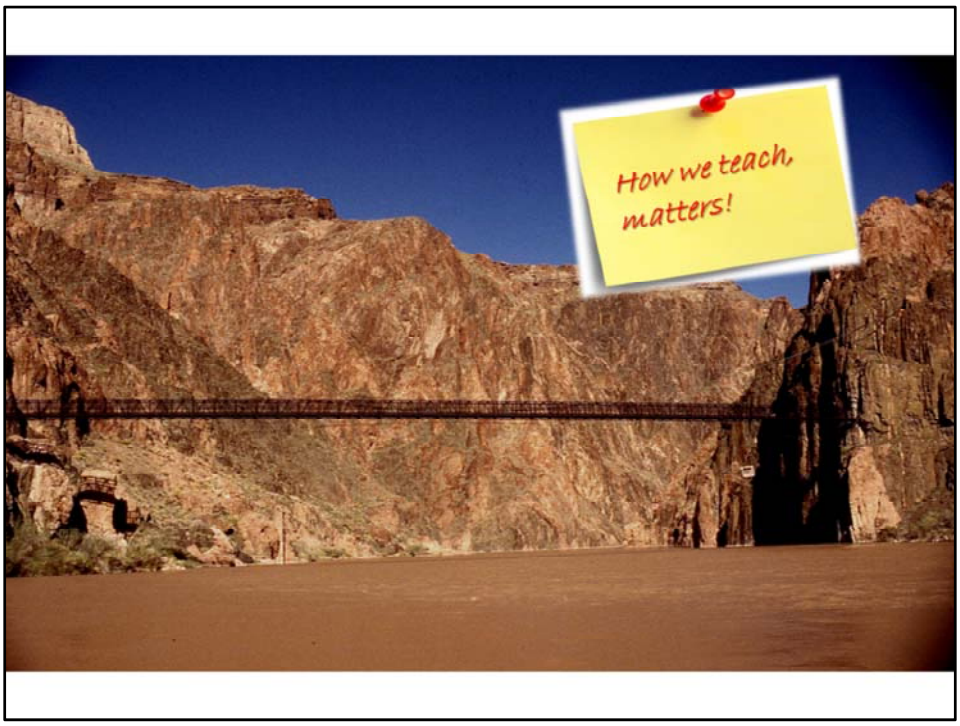
Harackiewicz et al., 2014, *Journal of Educational Psychology*, 106(2): 375-389

Another case study in introductory Biology… this time from the University of Wisconsin at Madison. The intervention was a value-affirmation exercise of the sort some of you may be familiar with from research on reducing stereotype threat. All of the students in the course completed two writing exercises during the semester. Those in the self-affirmation group selected most important values from a list and wrote about why each was a personal value and how it related to their educational ambitions. Those in a control group selected three values of least importance and wrote about why somebody else might find them of value; so they were not affirming their own values.



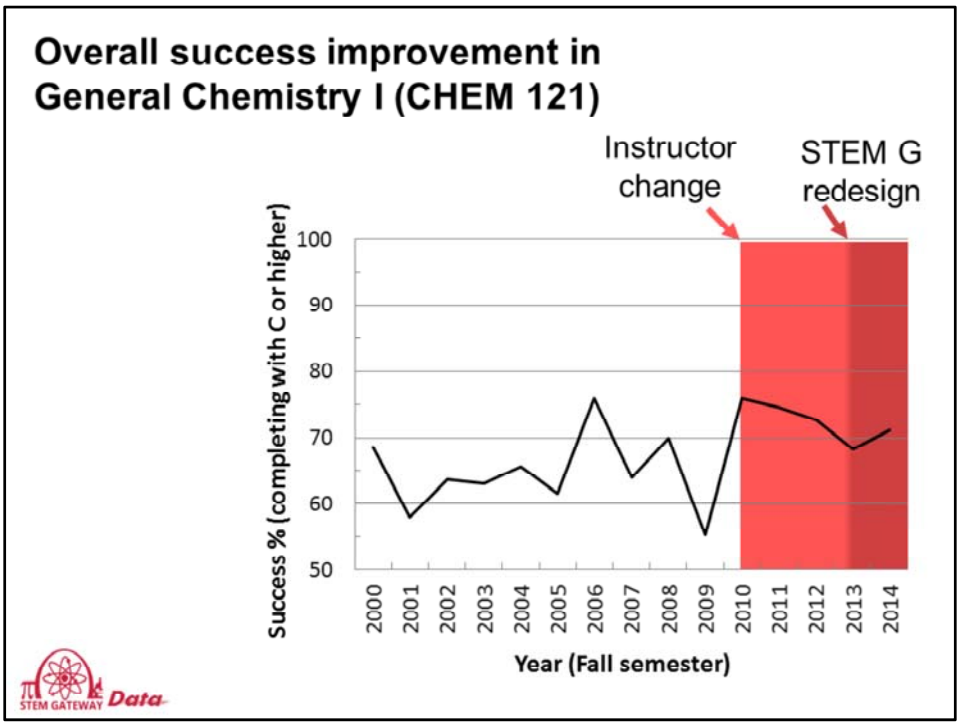
And here are three results for the control group. Once again we see the gaps – in course grade, overall semester grades, and continuing to a second biology course.

Now let's look at the group experiencing the value-affirmation intervention. First, notice that there isn't a change for the continuing-generation students – they already function well with their cultural knowledge of how to succeed. Not only were gaps diminished but the percentage of first-generation students continuing to the next course actually exceeded the continuing generation students. In the grade categories, the increase in the average for the intervention exceeded the control by more than one standard deviation ---- that's what stats folks call an effect size greater than 1.0 and that's virtually unheard of in education research. Just by asking students to undertake two writing assignments. Remember – Craig Nelson tells us that the things to do are easily accessible!



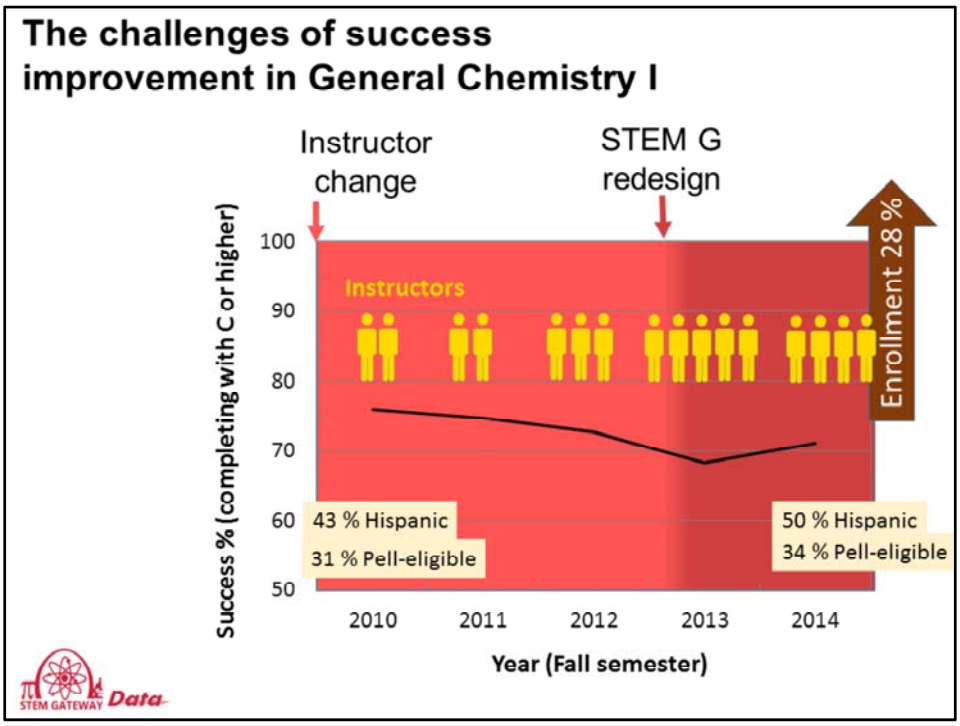
Key to the achievement gap is bridging the chasm between the culture of the university and those who bring plenty of motivation and intelligence but lack the cultural knowledge of the institutions.

I'd like to finish by bringing things back to UNM and the course redesign projects in the STEM Gateway project. We used the evidence from the redesigns at Washington and North Carolina and a ton of research on evidence-based inclusive pedagogies with the desire to bring about great achievements for our Hispanic and low-income students. To be honest … we've had some successes and we've had some challenges. Implementing the best practices with fidelity and consistency has been difficult for many of our faculty. **Let me show you one example.**



The first semester of General Chemistry is required by 25 degree programs at UNM --- that's a true gateway course. The percentage of students completing the course with a grade of C or higher averaged around 65% for more than a decade … or in other words, a third of the enrolling students did not receive the necessary grade to proceed in their major courses. But there was improvement in recent years.

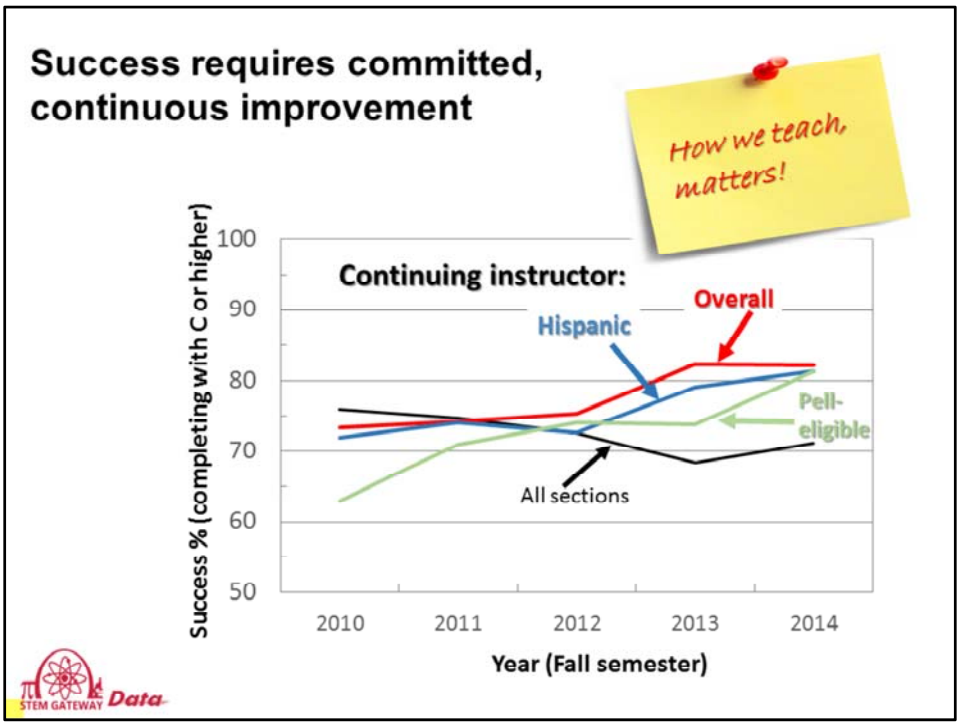
The big change took place when the instructor teaching the largest sections made the commitment to completely overhaul her course in close consultation with the Office of Support for Effective Teaching. She was also influential in bringing her colleagues together for a STEM Gateway Redesign project. You might be thinking that the impact of STEM Gateway is pretty unimpressive in this graph. But let's look a bit deeper in what happened during 2010 to 2014.



First of all… there were significant ongoing challenges during this period.

Overall enrollment in the course ballooned by 28%
Also increasing were the proportions of our targeted population of Hispanic and low-income students.

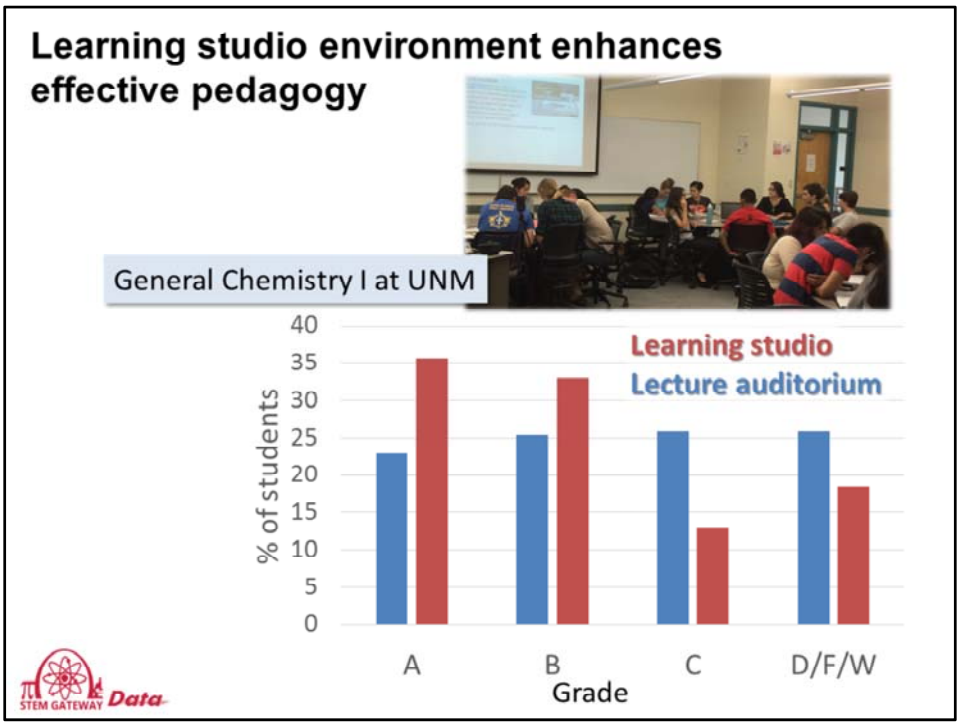
But even more notable was what was happening with the instructional workforce for Gen Chem 1. Not only did the number of instructors increase, but only one person was a part of every one of these instructor cohorts. It's hard to develop and sustain instructional change when the instructors are changing, too. To their credit, this is a remarkable group of instructors – none of them tenure track, most of them temporary part timers – who meet together about weekly to discuss what's working and what's not and sharing potential solutions for improving student success. But only one of them has had the consistent opportunity to improve and that's the instructor that started this transformation in 2010. Let's just look at her results.



The black line shows the pattern from the previous slide and the red line shows her success rate, which has been climbing and going above the 80% success rate that we set as a target for STEM Gateway. Notice also the gains for our two targeted student groups and the narrowing of the achievement gap.

Finally… let's examine what happened at this dramatic bump between 2012 and 2013.

That's when this instructor took her largest class section into UNM's studio classrooms. Spaces designed for interdependent learning that matches social constructivist learning theory dating back to the Greeks and the interdependent values of first-generation students. Rooms that are so different from lecture halls that there isn't even a front to the room.



And the shift in grade distribution was substantial. Not only did the pass rate improve but the percentage of As and Bs increased and that's important. Just slipping by with a C likely doesn't hearld success in upcoming courses --- mastery needs to be greater.

So – How we teach matters. But, I also argue that for us to reap the benefits at UNM we need to make student success the business of the faculty and we need to support faculty effort, initiative, and innovation to make the necessary changes. We invest greatly in advisement software and data analytics of our students' successes and failures but are we really investing in how we teach?

What questions do you have?

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