

Opening the Gateway to STEM Disciplines: 2017.03.16.0200.Epperson

Notetaker Name: Brandy Wiegers Email/Phone: brandy.wiegers@cwu.edu / 530-220-0324

Speaker's Name:

James Epperson (The University of Texas at Arlington), epperson@uta.edu
<http://www.uta.edu/faculty/epperson/>

Talk Title:

Opening the Gateway to STEM Disciplines: What Have We Learned From the Arlington Emerging Scholars Program (A-ESP) in Calculus?

Date:	03/16/2017	Time:	02:00 - 03:00	pm
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Materials:

- Detailed notes from notetaker (pdf)

List 6-12 key words for the talk:

Equity, Emerging scholars program, Calculus, STEM retention

Please summarize the lecture in 5 or fewer sentences:

This talk summarized the impact of UT Arlington Emerging Scholars Program (A-ESP) in Calculus between Spring 2010 through 2014. The presentation began with a review the Treisman-style emerging scholars program that have developed since the 1970s with specific focus on the adapted modeled used by UTA. Results of student evaluation and long term analysis of the student population showed that A-ESP showed higher grades, no significant difference in STEM retention and STEM graduation.

Detailed Notes of Opening the Gateway to STEM Disciplines:

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Opening the Gateway to STEM Disciplines: What Have We Learned From the Arlington Emerging Scholars Program (A-ESP) in Calculus?

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Arlington Undergraduate Research-based Achievement for STEM (AURAS) at UT Arlington

Goal: Increase the pipeline for STEM Careers for US citizens and permanent residents who are first time, first semester university freshman intending to major in physics, mathematics, chemistry and engineering.

A major component of AURAS involved implementation of the Arlington Emerging Scholars Program (A-ESP) in precalculus, calculus and chemistry.

PI Team: Lynn Peterson (PI) with Co-PIs: James Epperson (Math), Kevin Schug (Chemistry), Ramon Lopez (Physics), and Carter Tiernan (Engineering)

Emerging Scholars Programs (ESP): Treisman-style programs (more widely known as Emerging Scholars Programs) are grounded in Uri Treisman's original research from the 1970's at UC Berkeley. He looked at conjectures for what was for differences in mathematical achievement between two groups of students in calculus at Berkeley. He found that African American who were over represented in the group identified as doing poorly in calculus and Mandarin-speaking Chinese American who were over represented in the group that was identified as doing well. (Treisman, 1985).

To get funded for the ethnographic study they had to come up with hypothesis about what this work was going to be about/ conjectures about why these differences exist (Treisman, 1992):

- Differences in motivation - certain groups of students that are "super" motivated and others that are not.
- Inadequate preparation - some students go to schools that don't have solid training in mathematics.
- Lack of family support for or understanding of higher education
- Differences in Socio-economic status

What he found from this work was that none of these were true when comparing the two groups. Instead he found that the differences in performance between the two groups rested in their beliefs about what their idea of "studying math" meant. Emerging scholar program (known as PDP program at Berkeley) was begun as a way to address this.

What did this mean? Treisman identified the following barriers to success:

Those students who were overrepresented in doing poorly were:

- Working in isolation
- Compartmentalization of daily life into "social" and "academic" components.

Those students who were over represented in being successful had integrated academic and social life and also spent time working by themselves and working with others.

Central Themes in ESP/"Treisman-style" programs: Collaboration/ Community/ Mathematical Challenge (Epperson, 1999; Treisman, 1992). Students in Treisman program are working collaboratively (in groups) on challenging mathematics. The program tries to have the students work to join a community of practice, being in a classroom with shared academic interest. Traditionally these have also been grounded in increasing

numbers of students historically underrepresented in STEM, whether that's nationally or in the the regional specific area (such as focus on bringing in more Appalachian students).

Model programs feature:

- Increase class time
- More personal contact with peers, graduate students and faculty
- Foster a student community
- Challenging work
- Specialized academic advising

The Emerging Scholars Programs (ESPs)

- Immediate goal is to increase number of students excelling in calculus or precalculus.
- Typically, ESP intensive sections meet for a total of four to six hours per week in addition, whereas non-ESP discussion sections meet for a total of two-hours per week.
- The ESP sections also meet for two hours at a time (rather than one), allowing students to work on complex mathematical tasks that require perseverance.

Local Setting: University of Texas at Arlington

- 5th among national universities for undergraduate ethnic diversity in 2017 (US News and World Report)
- Large urban university (currently 41,000 students with approximately 25% graduate students), with a student body that is 25% Hispanic, 15% African American, 10% Asian American and 12% International.
- Hispanic serving institution (HSI)
- Data collected over the period 2010-2015.

2010 Data:

- Precalculus: 3-hour course, 15-week semester, lecture-based
- Calculus I & II: 4-hour course, 15-week semester
 - Three hours per week of large lecture (80 to 110 students)
 - One-hour recitation (40 to 55 students) per week led by a graduate student
 - One-hour problem solving lab (40 to 55 students) co-facilitated by graduate student and lecture
- There was large sections at this time period due to budget restrictions.
- Identified as high-loss courses: DFW (grade of D/F or withdrawal from course) rates above 50% so this was a good place to start if you're trying to look at the pipeline.

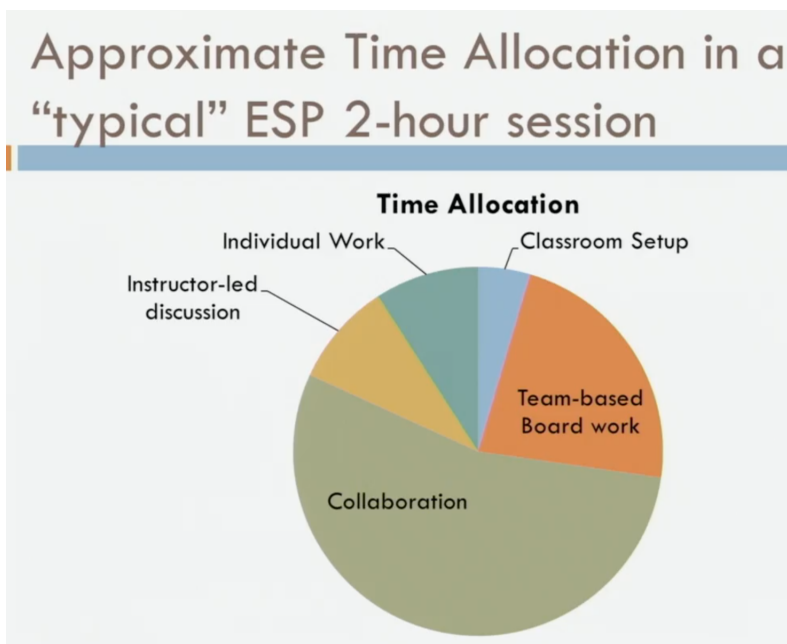
A-ESP in Mathematics

- Academic year experience:
 - Fall Precalculus A-ESP - Spring Calculus I A-ESP
 - Fall Calculus I A-ESP - Spring Calculus II A-ESP
- Variation from "traditional" ESP model:
 - Recruitment for Spring Calculus I A-ESP included all students meeting our target group profile with a DFW in Fall Calculus I (regardless of Fall participation in A-ESP)
 - Recruitment for Spring Calculus II A-ESP included all students meeting our target group profile with a C in Fall Calculus I (regardless of Fall participation in A-ESP)
- Different approach from "traditional" ESP model due to recruitment strategies. UTA decided that because of NSF funded work was going to target at-risk students, not just targeting by racial group because there was concerns for all students, across the board. Looking for students that were at risk by several factors, not just "skimming from the top" (taking students that should be doing well and making sure that they do well).

Structure:

- one additional two hour workshop per week (instead of two hours and then still class, recitation, problem solving lab, etc).
- Also graduate student ESP instructor with 2 smaller sections (25 students) enrolled in one large lecture section) assisted by 2 undergraduate student assistants
- Still had ESP components: Challenging mathematical tasks, community, collaborative learning environment (worked in groups).
- Recruitment: Targeted students broadly at risk.
- Targeted boardwork: In classrooms with plenty of boards to work so they started class in groups on the board.

Time Allocation:

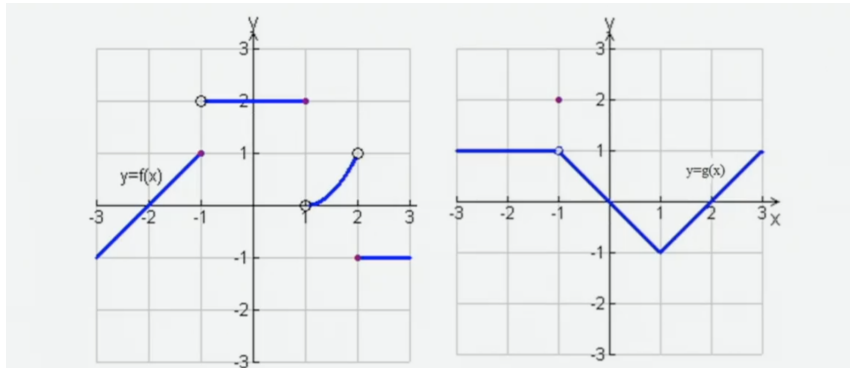


Classroom setup - move tables around, handout homework, etc.

This is basically what you expect to see in an inquiry-based classroom with some time for instructor to come to front and clarify.

Example ESP Task: This might be done in the first two weeks of the program.

For the functions f and g shown, list at least five mathematical questions about f, g , or both. At least two of your questions should involve recent ideas from class about limits and continuity. Epperson note: When Rochel was thinking about rehumanizing I was thinking about this task and their questions.



- Next, as a group answer the questions you posed.
- List any surprises or interesting mathematical outcomes you encountered in answering the questions you posed and explain why you were surprised or found the result interesting.

One of the things students do in class is spending time explaining to each other, writing out work, and some of these other aspects we've been discussing throughout the conference.

These tasks then continue to build on this with variations of the problems. The TAs go through training to think about how to adapt the problems for their setting. First was looking at limits/continuity. From there we look at composition. Then we finish up with the composition limits/continuity. It's all building.

One of the things we talk about with the instructors is giving them specific mathematical student responses to be looking for (see Smith and Stein book, Five Practices for Orchestrating Productive Mathematical Discussions)

Evaluation: Polling the students on what the students value

They did an anonymous questionnaire to ask the students what the most beneficial things were for ESP to see if they aligned with the Collaboration/ Community/ Mathematical Challenge themes that the program was designed around. They used open coding to look at all the responses and put them into categories.

Why were the primary reasons you joined the AURAS A-ESP workshop?

- 50% of responses mentioned one or more of the following; receive extra help in problems, receive more practice on material, more challenge and better understand concepts.
- 14% of responses mentioned chance to earn higher grades, gain an advantage, or pass the course.

How did you hear about the workshop

- 71% Advisor or freshman orientation.
- 14% listed personal email, flyers, and announcement in class.

What did the students value? Based on a scale from 0-10 (where 0 is no effect and 10 is profound effect) rate how each of the following affected your experience in your math course.

- Personal relationships (67% rated it >7, 44% rated it at 10). This is the biggest one.
- Extra time in workshop (72% rated it >7. 33% rated it at 10).
- Outside assignments: (40% rated it 7. 18% rated it at 10). Extra homework created by graduated students who believed they needed to make the homework to hold students accountable. Students didn't like it.
- Problems on worksheets (65% rated it >7. 27% rated it at 10).

- Practice exam problems (79% rated it >7. 46% rated it at 10).

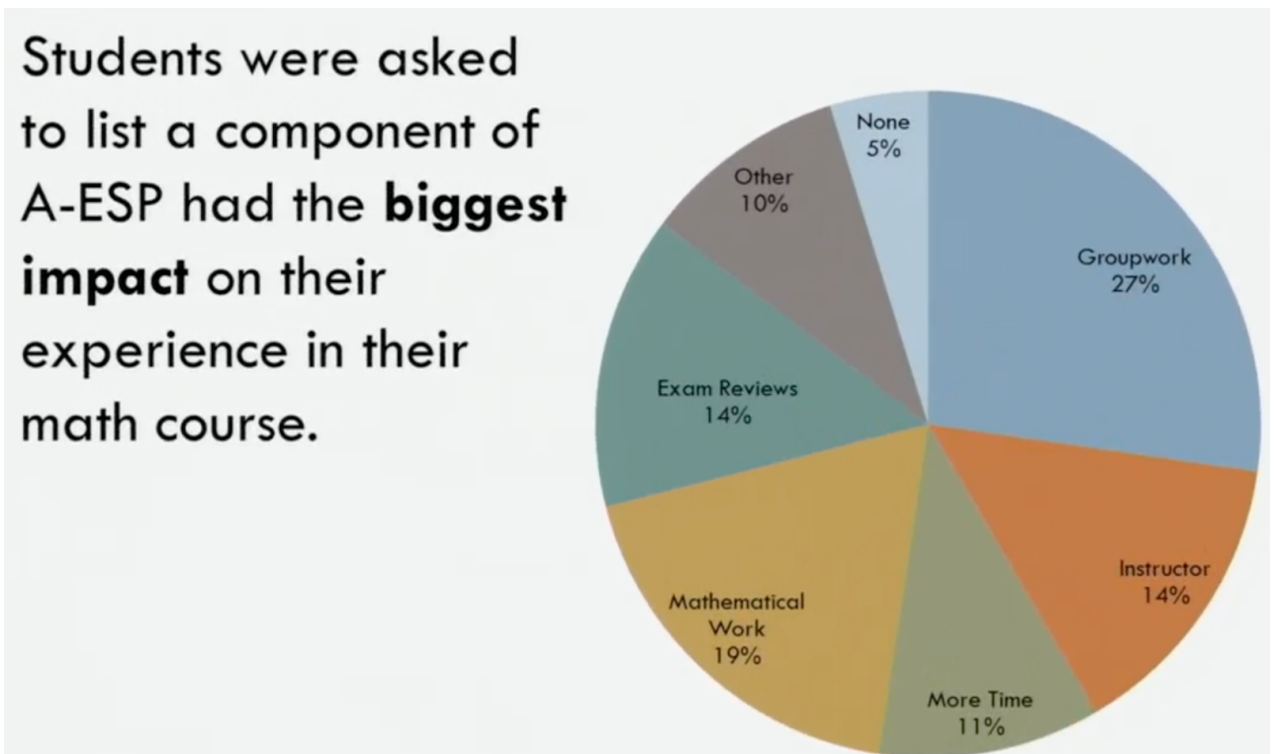
Were there other things that were particularly effective that weren't listed? They listed:

- Outside of Class midterm reviews (16%): Big "party" held before reviews.
- Working in Groups (25%)
- Graduate student instructor (32%) - affective component, instructor matters.

When asked to list components of A-ESP that were ineffective:

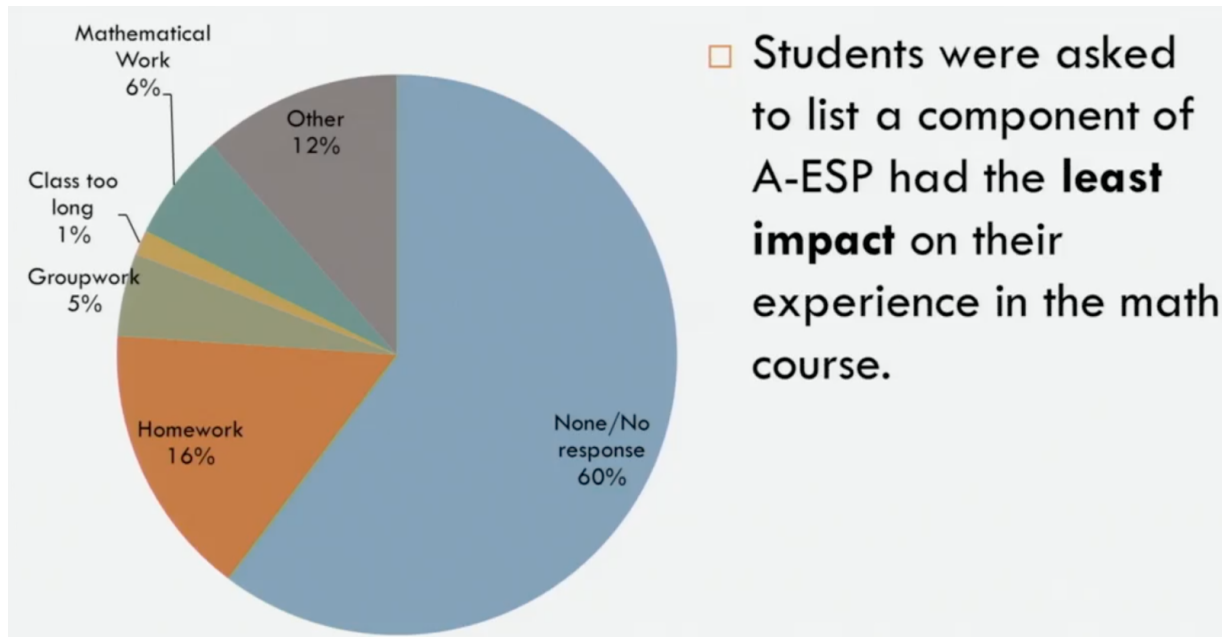
- 79% gave no responses or indicated "none"
- Worksheets and A-ESP homework (8%)
- Aspects of groupwork (5%) - sometimes I felt I had to carry my group or my group carried me

Impact



- Note that the humanizing aspects are the biggest categories:
 - Group Work (27%)
 - Role of instructor *14%
 - More time for mathematically challenging work (11%)

- Least impact:



- 60% None
- 16% Extra homework
- 5% groupwork
- Mathematics - too hard

- "Biggest impact":

- "Friendship and camaraderie with people who take the class seriously and observe difficulties they may have". Had an opportunity to witness math being done.
- "It made it easier by improving my study habits"
- "Working in groups to bounce off each other. Weakness and strength discovered"

- Would you recommend A-ESP to a friend?

- Yes, it gave me time to learn math with others... everyone had a chance to teach and learn.

Survey was longer but this gives you a nice sampling.

Effects of A-ESP

What do we know about the effects of A-ESP on student performance and STEM retention.

Discuss with your neighbor: What do you think we found? How did it affect STEM retention? How did student performance of A-ESP students compare with non-A-ESP students?

- We hypothesize greater persistence and retention - some good immediate impact but more broad/long-range
- Expect to see an uptick in retention rates. We found that your first experiences in university mathematics, if they're positive constructive experiences then in our university they're more likely to take more math courses. It's that first experience, that's when you lose them from STEM fields.

What did the data say?:

Total Number of Students Without Repeats			Total Number of Students in Target Population		
Course	Semester	Number	Course	Semester	Number
PreCal	Fall	894	PreCal	Fall	152
Cal I	Fall	2086	Cal I	Fall	669
Cal I	Spring	1419	Cal I	Spring	345
Cal II	Spring	1563	Cal II	Spring	477

Target Population: first-time first-semester freshmen who are US citizens or permanent residents intending to major in physics, mathematics, chemistry, or engineering.

- Precalculus Data: Fall '10, '11, '12, '13
- Calculus I Fall Data: '10, '11, '12, '13, '14
- Calculus I Spring Data: '11, '12, '13, '14
- Calculus II Spring Data: '11, '12, '13, '14, '15

- Remember:
 - Look at target population (1st time/1st semester freshman in targeted majors).
 - Separated spring/fall courses because these are different student groups.

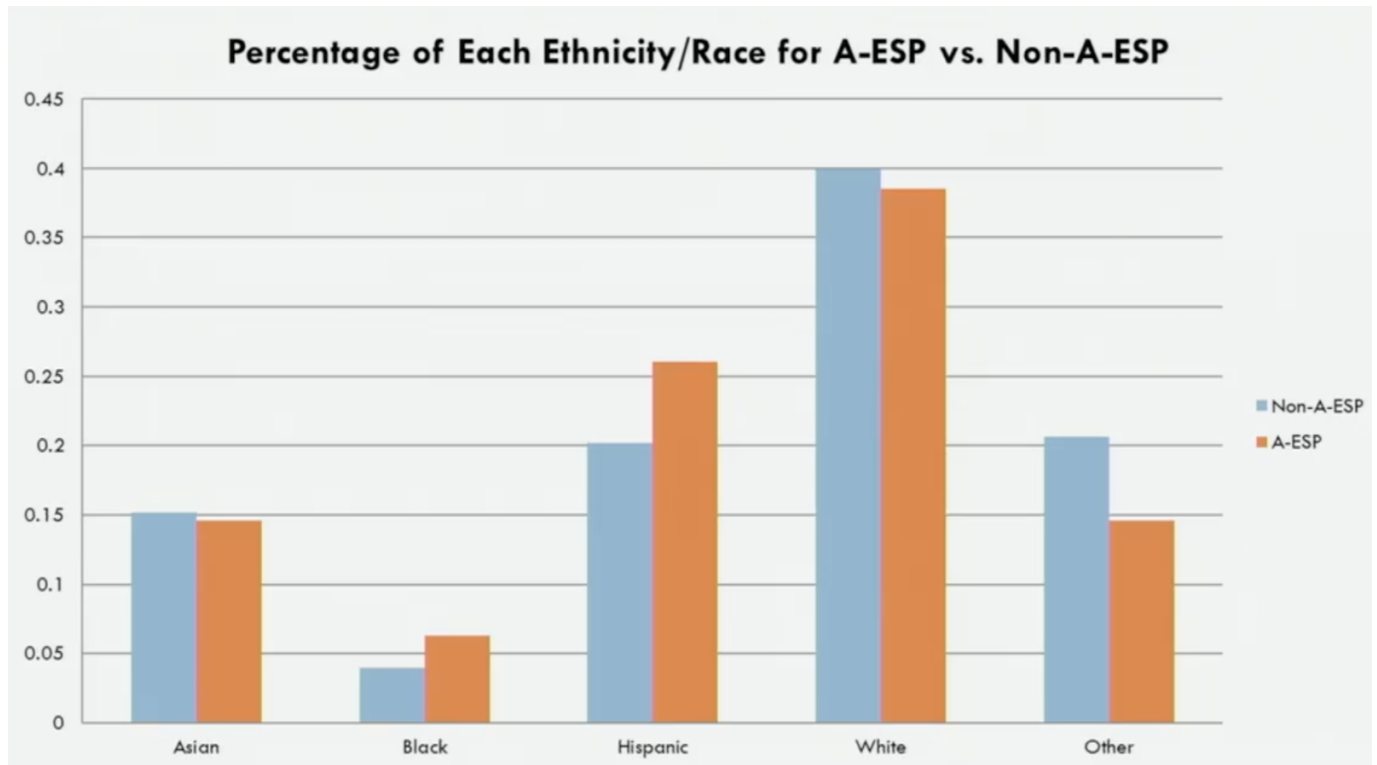
Results: A-ESP students earn higher grades, statistically higher between comparable groups, stayed consistent for higher courses (.05 level). Similar to 1990's research results from other ESP programs.

The rest of the talk will focus on Calc 1 Fall A-ESP data:

- Fall A-ESP Calc I students had higher success rate (Grade A/B/C) than those not in ESP by $\alpha=0.05$ level. Odds-ratio (1.831) suggests that they have an 83% higher chance of success if they're in ESP.
- Students in Spring A-ESP Calc I also had higher success rate (Grade A/B/C) than those not in ESP at $\alpha=0.05$ level that was significantly significant.
- Did A-ESP recruit stronger students?
This is a natural question so to try to address it they looked at AP-Calculus scores. Based upon reported AP-Calculus scores students reporting a score of 3 or greater on the AP-Calculus Exam were less likely to be in the A-ESP at $\alpha=0.05$ level. So they didn't "skim the top" based on this measure.
- A-ESP and STEM Retention:
STEM retention sampled for all students similar to A-ESP target group by looking at major code as of Spring 2015 (does not include Fall 14 / Spring 15 cohort) and comparing to original intended major. Although we only target a selected subset of STEM fields for recruitment into A-ESP, students were considered to have been retained in STEM even if their STEM field as of Spring 2015 was outside our original targets. So a Physics/math major that was a biology major in 2015 was considered retained.
 - Found no significant difference between ($\alpha=0.05$ level) the A-ESP and non-A-ESP groups.
 - However, since A-ESP increases chances of succeeding in the gateway courses, this may be interpreted as a leveling effect possibly attributable to A-ESP participation.
- A-ESP and STEM Retention:

We found no significant difference ($\alpha=0.05$ level) between the A-ESP and non-A-ESP groups.

- Since A-ESP increases chances of succeeding in the gateway courses, this may be interpreted as a leveling effect possibly attributable to the A-ESP participation
- Linking effects of a program in the freshman year to graduation rates is problematic. There is some evidence that having a good freshman year is good but it's too far in the future to attribute that effect.
- Impact of Gender:
 - All Calc I students meeting our target population profile: 20.% female, 79.8% male
 - A-ESP Cal I students: 20.8% female, 79.2% male.
 - Gender had no impact ($\alpha=0.05$ level) on grade earned.
- Impact of Ethnicity/Race:
 - For our entire target population in Calc I, being Asian was an advantage ($\alpha=0.05$ level).
 - In A-ESP, no conclusive evidence that ethnicity plays a role in success in the course.



- For African-American student they doubled the participation in A-ESP
- “Other”: Biracial, other races not listed, and anyone who left it blank.
- Impact for First Generation College Students:

First generation college students were defined as those students for whom neither of their parents graduated from college.

 - First-generation status was a disadvantage for non-A-ESP students ($\alpha=0.05$ level). But, had no statistically significant status for A-ESP students. If you were in A-ESP it erased the possible disadvantage.
 - That held if first generation college students were redefined to be those who had neither parent who had never gone to college at all.

Other Important Aspects of A-ESP that won't be discussed today

- Advising: Getting students in right courses, getting them to participate

- Instructor training: having instructors think about what kind of work they give students to do, how to manage group work, how to be sensitive to social class, racial tensions, gender issues.
- Peer Academic Leader (PAL) training: Preparing the two undergraduate student assistants (2 day training). These are recruited from year before, learn how to facilitate, learn how to interact in a positive way, learn strategies TA has as they made the worksheet, what are good hints, what are not good hints.
- Scheduling, appropriate classrooms: Few classrooms with moveable chairs for group work, blocks of time to have the classroom.

Audience Questions:

Q: What were barriers/risk factors: what looked at when talking with advisors about who to recruit to A-ESP

- Last math class in high school
- Test scores
- Wanted to encourage a diverse pool of students. It was difficult to target specific groups when you need to use advisor to really encourage that they take advantage of the process. For example would have loved to have more African American students in the A-ESP but it was difficult to explain that to the recruiter.

Q: If you could change the treatment of the study, how would you do it?

- Their performance in the class was statistically significantly higher.
- Retention - more time with advising aspect
- Mentoring - more time with the mentoring aspect - have more scientists come in to speak with students so the students can identify and use those relationships with professors to connect mathematics to STEM discipline.

They also did have secondary component of post A-ESP opportunities. After ESP the students could become student research, money were available. They used this as carrot to keep them involved/opportunities to work with professor. \$1000 to student, pay student to work in their lab. The professor got a free assistant. They haven't linked that to that being part of the success.

Q: Some approaches where the treatment is based on what we've learned from research about the program. What if there had been more time spent in the problem definition page - learn about the challenges that the students are facing to design the program to meet the needs? It's possible to have the design based on traditional research (basic things) but then the design can be based on what we can learn from others who work with these students. For example, get some input from K-12 environment/ input from parents/input from social services who are interacting with these kids. There could also be other problems are beyond the instruction. Other areas on how the learn/how they study that impact their performance.

A: Design could be impacted. They do have data on how many hours they're working outside in other jobs. Part of what the TAs were instructed was to know as much as they can about what is going on in the students' lives. They were then to help intervene, get them to a counselor, financial aid office, there were these other interventions built into the program in an informal way.

Q: Peer Academic Leaders: Do you have any feelings about the impact that this had on PALs who participated?

A: We're looking into that. It's a small sample but we're looking at that in a qualitative way.

- Accommodations to local context:
 - Redesigned precalculus to closer mimic what they'll be doing in Calculus.
 - 4 hour precalculus course
 - 1 hour problem solving lab led by graduate student assisted by up to two PALS
 - 1 hour recitation
- **Adaptations to A-ESP model to increase participation while minimizing cost per student (mandate from university).**

Lessons learned?

- The ESP model has been used widely over the last 40 years and various studies have shown that ESP participants earn higher grades (Bonsangue, 1994; Moreno, Muller, Asera, Wyatt & Epperson, 1999; Duncan & Dick, 2000; Drane, Smith, Light, Pinto, & Swarat, 2005).
- Our data supports the idea that the model may be appropriate for at-risk students and can be effective with as little as two additional hours per week.
 - We do show students earn higher grades but it's a different population of students.
- Need more studies to be conducted that provide evidence that investments in programs like A-ESP, while seemingly costly per student, actually cost less by increasing pass rates (c.f. Bonsangue, 1994).

Equity Connections:

- Rehumanizing mathematics (Gutierrez, 2017):
 - Collaboration - this is what the students valued most.
 - Community - students bond
 - Mathematical challenge- Use different ways to communicate math within the mathematical challenge. (multiple representations, present out, talk about math together)
- Student opinions support these rehumanizing aspects as the most effective or productive aspects of A-ESP.
- Student achievement data supports effectiveness of A-ESP for all groups of students - how do we use this to increase the pipeline for historically underrepresented groups? It's difficult. In our setting we have a particularly diverse student body so if we were to have A-ESP match the student body it would go a long way. We're there for the hispanic students and need to improve for african american students.

Q: It's clearly quite effective, meeting a lot of the aims you set out to meet. What would it take to scale up this work, to meet more student needs. What have you learned for would it take for other institutions to do this? This is a complex intervention, expensive intervention. Even with an ROI, it seems like a big lift.

- We're still discussing this. As our funding source is ending (in the final extension this year) we're toying with how to reach more students is to embed in the "regular" sequence by changing the 1 hour recitation to a 2 hour problem solving session. Would take training TAs to do more problem solving in this setting. Will need to do more research to see if that will actually be effective.
- Cost: it's a costly program... it's a tough question but hard things cost money. We were able to touch 13% of students of the population we were after, small proportion of students. There is a question about if scale up even work? More students forced to be there. We plan to study if we did create a

situation like that then it's important to keep the 2 hours of extra work well structured and not just made it extra work. Try to study that

Q: Has your university made a commitment to continue the funding

- No

Q: Are the results of the research study made you rethink the pedagogy in the regular class as they're teaching it.

- Yes and it's a challenge when you're thinking about dealing with faculty and academic freedom. Freshman retention is so important to our universities so there is more effort to even make lectures that are active.

Q: How are the graduate students selected/ self-nominated. Have you thought about studying the impact on the graduate students, how are they progressing as they learn to teach in specific ways. As they see themselves as mathematicians and math teachers how is affecting them?

- They handpicked the graduate students in the program: looked at pool of students, looked at their teaching, and they were representative of students they were trying to serve.

Comment: This might have been an opportunity to have been taught by someone who wasn't a white male.

- Shandy and Natasha Spear has done some work on the impact on the graduate student instructors who have participated in teaching in these kinds of programs. There is work on this, I just didn't do it/

Comment; I'm a big believer of ESP, I'm a product of ESP and was a graduate student instructor, so I want to push this community, in what ways is this equal treatment for all versus equitable treatment? Why is not a silver bullet that we're doing for everyone? Be thinking of how we're attending to differences in an ESP program. Maybe through teachers, don't know but don't accept this as the silver bullet that will solve the equity issue.

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