Lessons Learned: Using Modified Emerging Scholars Program Concepts in the Development of STEP Grant – Funded Initiatives

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Introduction

AURAS, the Arlington Undergraduate Research-based Achievement for STEM, is a project undertaken at The University of Texas at Arlington (UTA) under a STEP grant from the NSF. Since the goal of the NSF STEP program is to increase the number of graduates in science, technology, engineering and math (STEM) majors, it was recognized that success in entry-level courses was a necessary first step in improving graduation rates of students majoring in Chemistry / Biochemistry, Physics, Mathematics and Engineering. Freshman-level courses in math and chemistry (Pre-calculus, Calculus I, Calculus II, General Chemistry I, and Chemistry for Engineers) were targeted for intervention because of their high drop and failure rates. The Emerging Scholars Program (ESP) model was used to develop courses that were then offered to incoming freshmen beginning in Fall 2010. A second component of the project was the development of undergraduate research opportunities for students who completed the ESP courses. Finally, research in STEM education was a third stated goal of the AURAS project.

Marked improvements in pass rates and a decrease in the drop rates for the participants in the AURAS classes were noted during the first three semesters (see Fig 1). Since plans for institutionalization was a requirement of the STEP funding, efforts were made to make the AURAS classes less costly, so that they could be sustained in the institution only by the funds generated from tuition of students retained. However, it became apparent at the beginning of year 3 that major revisions were needed with a focus on sustainability if the promise of the grant funding was to be attained. Three initiatives were initiated: mathematics course redesign, institution of an engineering problem-solving class, and further development of research methods components. Each of these initiatives was successfully completed and fully institutionalized.

Now, at the conclusion of the AURAS project, the team is taking stock of lessons learned from this work, including cultural changes in the colleges of engineering and science, classroom modifications that resulted from demonstrated improvements, and a more widespread recognition of the importance of a more scholarly approach to science and engineering education. In the following, we detail some of those lessons learned.

Lessons learned regarding design and management of courses

The central features of the ESP model are a problem-based approach to learning with a focus on high-level work rather than remediation, a welcoming community with shared academic interests, collaborative learning and small group interaction, with an underlying goal of increasing diversity by increasing minority student successes. In addition to the regular lecture and labs associated with the courses, ESP students were required to attend two two-hour ESP recitation sessions per week for Pre-calculus and Calculus I, one two-hour session for Calculus II, and one four-hour ESP session per week for Chemistry. Note that these recitation sections were in no sense remedial, but consisted of challenging problems related to the topics being treated in lecture.

Project focus. We found that, as Fig 1 shows, students in the ESP sections of the Pre-calculus (MATH 1323), Calculus I (1426) and Calculus II (2425) courses showed markedly better pass rates. Since these courses are required in all of our target STEM majors, success in these courses was a necessary component of improving STEM graduation rates at our institution. We felt that the decision to focus on the introductory math courses was, for us, the correct approach. Likewise the General Chemistry I (CHEM 1441) and the Chemistry for Engineers (1465) courses also demonstrated substantially better pass rates for ESP students.

Fig 1. Pass rates / drop rates in the first three semesters' implementation of ESP courses

U Texas Arlington Composite Results Table Fall 2010 thru Fall 2011

Fall 2010, Spring 2011 & Fall 2011 composite

Course		A	B	C	Pass	D	F	I	Q	W	Drop	Total
Math 1323*	ESP	5	16	6	56%	3	8	0	0	10	21%	48
Math 1323*	non-ESP (1)	13	14	24	35%	10	34	0	3	48	35%	146
Math 1323*	non-ESP (2)	57	84	96	42%	62	108	1	8	146	27%	562
Math 1426	ESP	21	19	18	75%	13	2	0	0	4	5%	77
Math 1426	non-ESP (1)	22	41	47	50%	26	36	0	2	47	22%	221
Math 1426	non-ESP (2)	108	260	252	44%	214	225	2	9	331	24%	1401
Math 2425#	ESP	5	4	9	72%	2	2	0	0	3	12%	25
Math 2425#	non-ESP (1)	12	11	12	65%	1	7	0	1	10	20%	54
Math 2425#	non-ESP (2)	32	52	47	52%	14	39	1	4	64	27%	253
Chem 1441	ESP	19	19	21	70%	11	8	0	1	5	7%	84
Chem 1441	non-ESP (2)	216	243	282	48%	176	309	4	13	289	20%	1532
Chem 1465	ESP	17	18	23	74%	7	10	0	0	3	4%	78
Chem 1465	non-ESP (2)	20	71	129	48%	66	82	2	5	82	19%	457
(1) non-ESP same section						* Math 1323 Fall 2010 and Fall 2011 only						
(2) non-ESP all sections						# Math 2425 Spring 2011 only						

Recitation sessions. In terms of the design of coursework, we found that intensive efforts like ESP can increase student success with only a 2-hour intensive session per week. We experimented with 4-hour sessions and found that a 2-hour session worked as well. This session was organized as a cohort-based collaborative learning session, keeping students in a cohort in both the regular recitation and lab settings.

Student grouping. We found that it was important for students to work in functional groups when solving problems. That is, each student had a task within the group. A useful strategy in this connection was matching stronger students with weaker students, especially if the former was adept at effectively helping the latter.

Attendance. In all of our ESP implementations, the number one metric of success in the ESP was found to be attendance. Those students who faithfully attended the ESP sessions were significantly more apt to achieve higher grades in the course, regardless of their prior preparation.

Recruiting. A continual source of frustration of the faculty team was convincing identified at-risk students to utilize the extra services that we provided. It was clear that the ESP sections involved more time and effort on the part of the student, and this was sufficient to drive students away. Many understood the likely benefit to their future success, but were not willing to devote that extra time and effort. Individual phone calls to incoming students on the part of the faculty team were often required to fill the sections. Recruiting is a component of the process in a new program that can often be overlooked; however, it can often be one of the most time demanding activities. Care should be taken to design programs where there is a straightforward and well-reasoned entry point for target students. As the ESP program at UTA matured, chemistry began to require all of its majors to enroll. This significantly reduced the recruiting burden for those students. We note that other institutions have had similar findings, so we provide yet another example.

Student assistants. Graduate student assistants and undergraduate peer academic leaders were used to guide problem solving activities in the ESP recitation sections. Training of these assistants, who were essential components of the program, was necessary for the program's success. As a by-product, those student assistants benefited enormously themselves. This has been shown repeatedly in the literature, so our experience was merely another good example of the phenomenon. However, we found that peer mentoring efforts should include a staff coordinator to facilitate pairing of students with mentors. We found that an ad-hoc approach does not work, especially when scaling up the classroom model to serve more students. We found that the creation of short one-and-a-half day training program for assistants could be an effective way to hone the facilitation skills needed to effectively administer the ESP program.

Infrastructure. Intensive intervention efforts work, but they must be supported by infrastructure changes (e.g., establishing credit for extra time, appropriate classroom settings, scheduling) and buy-in from the administration. We realize that this is a "re-learned" lesson from previous work, especially that of Uri Treisman [1,2]

Lessons learned regarding authentic research experiences

As a mechanism to positively influence the number of graduates in STEM majors, the AURAS project actively supported undergraduate research experiences, which we termed "authentic research experiences". Throughout the years of the grant, students in science and engineering who succeeded in the ESP coursework were given the additional incentive of supported undergraduate research.

Recruiting students. Not surprisingly, we found that freshmen students required significant prompting to consider and investigate the concept of undergraduate research if they were not familiar with it prior to college

Scaling up. Making undergraduate research available to large numbers of students is more difficult from a logistical point of view than it might seem. The logistics of finding interested faculty to work with undergraduates, finding interested students, 'vetting' the students, matching them to faculty, setting up the payment process from the grant, monitoring the student work within the grant payment parameters, and getting feedback on the research experiences can take significant time and management if the campus does not have processes in place to facilitate this.

Recruiting faculty. Faculty experience with the process is as important as student experience. It can help increase faculty willingness if they can see how to fit in the undergraduate without significantly increasing their workload. In particular, suggesting a supervisory structure, such as training their MS students to direct the young undergraduate students, can encourage faculty members to work with undergraduate students.

Matching. Assessing the commitment and persistence of the undergraduate students prior to matching them with faculty is helpful. Highly committed undergraduate students are much more likely to have a beneficial experience and to impress the faculty member they work with. Commitment and persistence are as important, if not more so, as knowledge and skill.

Lessons learned regarding research in STEM education

All of the faculty team members on the grant have a strong interest in STEM education. Two of the faculty members are in departments that have tracks for students to choose a discipline-based education focus for their Ph.D. research. However, the other team members are from departments that do not have this education option for their graduate students. There was a marked difference in how the different fields recognized the importance of the AURAS work.

Career impact. One lesson learned is that funding and support for educational programming and research are not a shoe-in for supporting the case of tenure of a junior faculty member in science at a research-intensive institution. This was because our STEP grant was one of the first of a STEM education nature at our institution. Fortunately, the decision was made that it would count favorably. Clearly STEM education in general relies heavily on both tenured and non-tenure-track faculty members for both instruction and educational research.

Publications. Our faculty team members who had graduate students working on the project submitted papers to various educational journals during the grant period. Some of these faculty members, with excellent records of publication in disciplinary journals, were not able to get their educational work published in the educational journals in their field. There was insufficient feedback from the journals to be able to determine why the papers were not accepted. This is in contrast to the peer reviewed, structured process for submission and feedback in most disciplinary journals.

Lessons learned by the faculty team

Institutionalization. The original plan for institutionalization had to be changed after several years into the project because of changes in institutional priorities. This was in spite of a strong positive impact of the program on student success. Therefore, we applied what we had learned to that point to develop new initiatives that could continue the AURAS mission [3,4]. These included mathematics courses redesign, an engineering problem-solving course [5-8] and inclusion of research methods into coursework. Indeed, these ideals have been assimilated into subsequent programs created by members of the AURAS team, especially in chemistry.

Faculty team composition. Forming a multi-department, multi-college team led to significant synergy and lots of spin-off effects, such as the expansion of discipline-based education research, a university-wide increase in focus on undergraduate research opportunities, and collaboration on other proposals. Though the AURAS team seemed to form organically, very early in the process the roles of the different faculty members became clear, and the success of the overall program was heavily dependent on the individual initiatives towards advancement of each of the important program components.

Student feedback. It clearly helps to have student feedback regarding classes and the program as a whole. We did that via surveys and focus groups in the early days of the program, and occasionally thereafter. One student who volunteered to make a video of his experiences provided a strong endorsement of the ESP as implemented in UTA's Mathematics Department. The student, Zackry Engel, said "When I first came to UTA as a Mechanical Engineering major, I heard about this program called ESP that allows students who needed help to get more help and those who wanted more to get more. I joined the program because I needed more help. I absolutely fell in love with the program. They asked me to come back as a peer academic leader or PAL. …. This semester I'm thankfully graduating with my bachelors in math and plan to come back to get my PhD in Statistics. … ESP is why I'm a math major."

Results. Marked improvements in the pass rates and a decrease in the drop rates in early high-loss courses required of STEM majors was one of the objectives of the program, requisite to achieving the goal of the STEP program to increase the number of graduates in the STEM fields. To that end, the resulting change in retention rates for our College of Science (COS), College of Engineering (COE) and overall for our institution, UTA, is the most important outcome of the program. While the positive change in retention rates was clearly not all attributable to the AURAS program, it certainly contributed to the campus' efforts to make our students more successful. Table 1 below shows the retention rates at the beginning and end of the AURAS project.

Table 1. Comparative undergraduate retention rates for UT Arlington

Metric				COS	COE	UTA
Retention rate, 1st year						
	1998-2006			71%	69%	65%
	2014 cohort			80.45%	78.39%	71.40%
	2015 cohort			78.15%	78.50%	69.45%
Retention rate, 2nd year						
	1998-2005			60%	59%	55%
	2014 cohort			73.02%	69.29%	63.22%
	2015 cohort			71.47%	69.28%	60.67%

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