Impact of summer bridge programs on STEM retention at The Ohio State University

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ABSTRACT

The Ohio State University has run a multidisciplinary STEM bridge program for entering freshman for four years. The program emphasizes math, science, engineering, and communication subjects as well as college success skills. It exposes students to the rigor of college coursework and highlights the difference in study approaches from their high school experiences. Evening professional development programs focus on study skills and resources available across the university. Results from this program indicate significant peer to peer bonding and creation of a support network that reinforces a student's motivation and drive to succeed. Although participants continue to change majors during their first year in school, they have shown increased persistence (retention) to majors in the STEM fields compared to a non-participant control group. This paper will discuss possible correlations between program activities and impacts as well as results of attitudinal surveys of the participants.

INTRODUCTION

We are in a time when improvements in undergraduate science and engineering education are a priority. Colleges and universities are in a position to support society by producing graduates who can make informed decisions about science and technology issues and can contribute to the science and engineering workforce. [1] In both his 2009 and 2013 inaugural speeches, President Obama called for a focus on science and technology as well as a transformation of our schools[2, 3]. In the global economy, the United States plays a key role in knowledge and technology intensive industries that rely on the continuous flow of bright young scientists and engineers into the workplace[1]. To complicate the matter, the price of a college degree is increasing at such a high rate[4] that many are questioning its value[5]. The National Center for Education Statistics reports an inflation adjusted increase of 42% at public institutions and 31% at private institutions (price includes tuition, room, and board) [4]. Articles in the popular press[5] highlight the fact that many students are taking on higher debt with the poorer prospects of employment following graduation. This brings into question not only how much it costs to go to college, but also how

can we help students get the most "bang for their buck" while they are in school? How can we help them choose a course that minimizes their time to degree while also maximizing their growth in the process?

We have chosen to address these economic concerns by supporting incoming freshmen STEM students in a summer bridge program. Bridge programs are a common method to introduce students to the rigor of college coursework and the study skills necessary to succeed in their chosen major. The National Science Foundation Science and Engineering Talent Expansion Program (STEP) provides support to increase the number students obtaining STEM (Science, Technology, Engineering, and Math) degrees at any level. Many STEP projects incorporate bridge programs as a method to improve the success and retention of students entering STEM majors. The Ohio State University STEP program (referred to as OSTEP) modeled its bridge program on an existing one offered by the Minority Engineering Program called PREFACE (Pre-Freshman and Co-operative Education program). While PREFACE focuses on under-represented minorities in engineering disciplines, OSTEP focuses on first-generation students and under-represented minorities in all STEM disciplines.

Even though little research has been conducted to evaluate the impact of bridge programs [6], previous suggest that summer bridge programs can have a positive effect on academic skills and self-efficacy [7]. Residential bridge programs provide an opportunity for students to develop along multiple dimensions[8]. First, they experience realistic coursework without the pressure of a transcripted grade. This allows students to discover how well prepared they are and usually proves to them that they don't know how to study well. Second, the common experience during a residential program builds a strong community among the participants that lasts well into their university careers. Others have reported that their summer bridge program appears to have had some impact on retention and recommend looking more deeply into impacts of the social aspects on retention [9]. We interpret these social aspects to be related to a sense of belonging.

In this paper we discuss results obtained from both qualitative surveys and quantitative indicators of performance and retention for three OSTEP/PREFACE cohorts who attended the bridge program in 2009, 2010, and 2011 (Cohorts 1, 2 and 3 respectively). We conducted a study to determine if participation in the summer bridge program could be associated with students (1) increased sense of belonging, (2) greater preparation for success as an OSU STEM major, and (3) retention in the STEM major until their graduation. We first describe the program structure followed by our survey methodology and then discuss our results in each of the three areas.

DESCRIPTION OF PROGRAM

The OSTEP/PREFACE summer bridge program (locally referred to as OSTEP/PREFACE) is a six-week residential bridge program. PREFACE was instituted in the early-1980s and OSTEP

expanded the population from strictly engineering to all STEM majors in 2009. As described above, PREFACE recruits nationally from the pool of admitted students underrepresented in engineering (African-American, Native American, and Hispanic). OSTEP targets recruitment of underrepresented groups, first-generation and Appalachian students in all STEM majors from the pool of admitted students. These groups have been targeted to enhance the diversity of degree seeking students in STEM. First generation students have also been identified as students that may need additional support to navigate university systems. Recruitment lists are shared to avoid recruiting the same student to both programs. OSTEP/PREFACE is a residential program in which students live in residence halls and attend rigorous classes, which model OSU's introductory STEM coursework. Students attend these courses, which include communications, math lecture, math recitation, integrated science, and visualization and problem solving, from 8 am – 4 pm. This includes a one hour lunch break and one hour break for free time. In the evening, students spend one hour in a professional development (PDP) course. The OSTEP and PREFACE cohorts attend classes together during the day but participate in separate PDP courses. All courses are taught by lecturers or faculty hand selected by the program managers for their effectiveness with students.

Both the communications and math courses have the structure of a common lecture and small recitations. This format is the most common format students will face during the academic year and it is important that they learn how to adapt to it. We find that the recitations allow students to receive greater individual, targeted attention.

We modeled the communications course after the freshman English (1110) series. In the communications course, students study written, oral and visual communication to learn communications concepts and skills. Students attend communications lecture twice a week and recitation on the alternate three days.

We divide the students into math recitation sections based on their performance on a math pre-test that they take the first evening of the program. This pre-test also serves as a baseline to measure student progress in math over the course of the summer. Math recitation occurs daily and immediately follows math lecture to help each group focus on their current skill set.

During the integrated science course, students take a two pronged approach in their preparation for the STEM majors. They spend part of their time investigating how STEM concepts are interwoven into answers to questions regarding dragonfly flight and habitat. Students collect and analyze data in real world situations with colleagues from multiple disciplines to help them learn the nature of science and the interconnectedness of concepts from multiple disciplines. The active learning aspect of the investigations should support student motivation and metacognition. In the rest of their time, a chemistry instructor guides them through concepts related to substances, pH, and metathesis reactions and students completed complementary labs. We hope

to hook the students while also exposing them to the realities of STEM classes through the combination of inquiry and traditional class experiences.

In the visualization and problem solving course (modeled on Introduction to Engineering), students learn to model in 2- and 3-D both on paper and using software. Students also develop problem solving and computational skills using Excel and Matlab software.

In the early evening, students attend PDP for one hour. This supplemental course is designed to provide students with additional resources to help them succeed at OSU. Students learn how to develop their study and time management skills as well as become familiar with campus and student life resources.

In addition to all of the organized courses, the program offers students the opportunity to participate in various on- and off-campus extracurricular activities as a group. Students learn to form study and social groups during their time in the residence halls. In addition, they often visit local attractions during their free time weekdays and weekends. The final group activity is an afternoon talent show in which all students participate. We hope that the combination of courses and unstructured activities will help students feel a sense of belonging to their OSTEP or PREFACE group and prepare them to succeed in and out of the classroom. If they are feeling like they are part of a group and succeeding in their major program classes, we anticipate that they will be more likely to graduate as STEM majors.

METHODOLOGY

We administer surveys to each cohort at the beginning and end of the summer bridge program and at the end of each subsequent academic year in Spring. These surveys inquire about motivation for studying STEM and for careers in STEM as well as attitudes and feelings towards school, studying, major, career choice and the impact of the summer bridge program. The surveys were adjusted significantly after reviewing the results from Cohort 1 so results are only discussed below for Cohorts 2 & 3. We also gathered all cohorts course grades for their first math and chemistry courses, which are frequent stumbling blocks for STEM majors. All procedures are included in approved OSU IRB protocol 2008B0087.

We determine a student retained to a STEM major if they are currently enrolled in Autumn quarter in a degree program or major in Engineering (ENG), Mathematics and Physical Sciences (MPS), or Biological Sciences (BIO). Since our project started, OSU has restructured MPS and BIO into the Division of Natural and Mathematical Sciences (NMS) in the College of Arts and Sciences (ASC). Engineering remains as a standalone College. This definition of STEM major excludes majors and degree programs in the College of Food, Agriculture and Environmental Sciences such as Animal Sciences, Environmental Science, Food Science & Technology,

Entomology, and Plant Pathology. However, our program does not include students from these programs nor have we observed any of our participants changing into these majors so their exclusion does not impact the results below.

For our experimental cohorts (OSTEP/PREFACE participants), we use the Student Information System to determine their current major after the enrollment census date (typically the 15th day of the term) each autumn. For comparison data, we obtain from the University registrar a "mobility table" describing the enrollment patterns for cohorts of entering "New First Quarter Freshmen" (NFQF). Some schools refer to this as new starts or first-time students. The mobility tables show the initial distribution of students among the different colleges (undecided students can still be enrolled in the college of their choice with few exceptions and are generally counted as intended majors in that college). The cohorts are then tracked as they progress through the university and each autumn, a new distribution of students among the different colleges is produced. In this work, we take the sum of NFQF enrollments in ENG, MPS, and BIO for Au 2007 as the incoming STEM cohort for comparison. Each autumn, we sum those colleges from the mobility reports to determine STEM retention for the university at large. Overall retention to the university is also tracked and is much higher than retention to STEM majors. Note that the experimental cohort (OSTEP and PREFACE participants) also shows up in the mobility tables but since the number of participants is very small compared to the total STEM population (<5%), it does not impact the university numbers significantly. Finally, for the experimental cohort students who are on leave of absence from the university in autumn (for work or other reasons) are not counted for the purposes of this project.

RESULTS & DISCUSSION

Mahar et al.[10] identify the following five elements "that are central to a transdisciplinary, multidimensional understanding of the sense of belonging": *subjectivity, groundedness, reciprocity, dynamism, and self-determination*. They define *subjectivity* to be when the individual feels that others value and respect them and the individual feels that they are part of a group. The authors point out that people could be participating in a group without having these feelings, so just observing someone being part of a group does not mean that the subjectivity element in the sense of belonging has been fulfilled. The *groundedness* element refers to the fact that the individual can identify name the specific group to which they belong. By being able to name the group, the individual has something concrete to anchor their sense of belonging. *Reciprocity* refers to the fact that the interaction and experiences with the group are shared. Mahar et al. emphasize that having shared physical, intellectual and behavioral characteristics might contribute to a sense of belonging, but they are not enough to fulfill the reciprocity element as the shared experiences, understandings, and beliefs do. *Dynamism* refers to the fact that there will always be changing factors that either increase or decrease the individual's sense

of belonging to a group. For example, in a higher education situation, once students start their freshmen year, they will be living and attending class with new and different groups of students. This dynamic situation may decrease their sense of belonging to groups to which they felt a strong affiliation prior to the start of their freshmen year. Finally, *self-determination* refers to individual's freedom to choose their affiliations as well as their power within those relationships. In other words, college freshmen's sense of belonging to a group is related to their desire to belong to that group and their belief that they can control whether or not they belong.

Sense of Belonging

The survey data from the closed response items indicate that the students agree that the subjectivity component of a sense of belonging has been supported in the summer bridge program with 98% of Cohort 2 and 94% of Cohort 3 students indicating that they made friends and 85% of Cohort 2 and 90% Cohort 3 indicating that they are more comfortable with science faculty. It appears that the groundedness component has not been as strongly supported with 68% of Cohort 2 and 56% of Cohort 3 indicating that they are part of a study group that will continue in the fall, but that is only based on one item related to student participation in study groups (see Table 1).

Table 1. Survey Results related to Subjectivity and Groundedness

Characteristic		Cohort 2 N=41				Cohort 3 N=52			
		Agreement with Item[1]		Mean[2]	S.D	Agreement with Item[1]		Mean[2]	S.D
		N	%			N	%		
Subjectivity	I made friends	40	98	1.29	.51	49	94	1.33	.65
	It made me feel more comfortable with science faculty	35	85	1.78	.69	47	90	1.67	.71
Groundedness	I am part of a study group that will continue in the academic year.	28	68	1.98	.82	29	56	2.42	1.02

[1] Percent of participants who indicated "Strongly Agree" or "Agree." Percentages are based on those with valid response to item.

[2] Lower mean score indicates a higher level of agreement as "Strongly Agree" was represented with a value of 1 and "Strongly Disagree" had a value of 5.

In Cohort 2, of the 33 comments made in response to an item asking what impact the program had on the students, 5 students referred to their association with friends, which we consider to be a component of the subjectivity element of the "sense of belonging." One student referred to himself as a Buckeye and one referred to his association with study groups, which we consider to be a sign of groundedness.

In Cohort 3, of the 44 comments to the same item, 8 students (8 comments) referred to their association with friends and new major, both of which we consider to be components of the subjectivity element of the "sense of belonging." Again in Cohort 3, one student referred to their participation in study groups indicating reciprocity. At this point, we have not measured the dynamism or self-determination elements of sense of belonging.

Even though most of the comments in the open response item were not related to sense of belonging, some students did make comments indicating they made gains in it. In the future, we will have to ask specific questions to determine if more students find the program supportive of their sense of belonging.

Preparation

Preparation was measured in two ways. Survey data from open and closed response items and grade received in the first Chemistry course. The survey data from the closed response items indicate that the students feel that OSTEP/PREFACE made them feel better prepared (see Table 2). It appears that they feel more comfortable with OSU and know how to access student support and academic resources on campus. Only 65% of the Cohort 2 students agreed that the program helped them improve their study skills, but that increased to 79% in Cohort 3.

Table 2. Survey results related to Preparedness

Characteristic	Year 2 N=41				Year 3 N=52			
	Agreement with Item[3]		Mean[4]	S.D	Agreement with Item[3]		Mean[4]	S.D
	N	%			N	%		

[3] Percent of participants who indicated "Strongly Agree" or "Agree." Percentages are based on those with valid response to item.

[4] Lower mean score indicates a higher level of agreement as "Strongly Agree" was represented with a value of 1 and "Strongly Disagree" had a value of 5.

Preparedness	It made me better prepared to succeed at OSU.	39	95	1.27	.55	50	96	1.35	.56
	It made me more comfortable with OSU	40	98	1.24	.49	51	98	1.17	.43
	I improved my study skills	27	65	2.22	.88	41	79	1.94	.92
	I have a better understanding of student support services available on campus.	39	95	1.59	.59	41	79	1.94	.92
	I have a better understanding of academic resources available on campus.	39	95	1.51	.60	45	86	1.77	.68

In Cohort 2, of the 33 comments made in response to the open-response survey item "what impact do you think this program had on you?" only 6 did not have some mention of an element of preparedness, and in Cohort 3 this was the case in only 5 of the 44 comments. In coding the responses to this item, several elements related to preparedness were identified including study skills, social interactions, comfort with content, what to expect from classes, and general preparation for college. The percentage of comments including each of these elements is illustrated in Figure 1. It appears that the program helped students be prepared primarily because of their clearer expectations of course work and campus life. Many students indicated that they are more prepared to study efficiently as a result in their participation in the program.

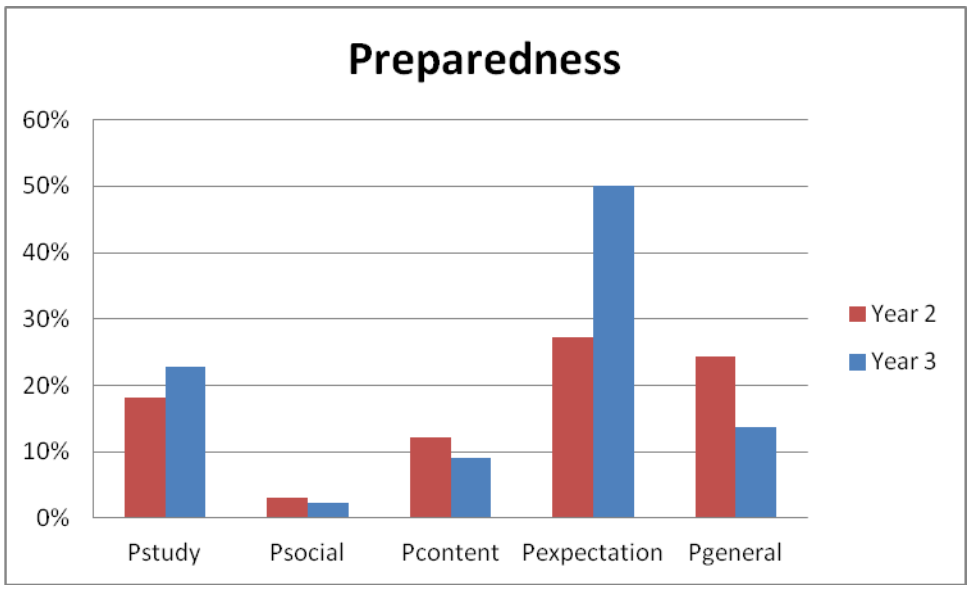

Figure 1. Percent of student comments that referred to elements of preparedness in Cohort 2 and 3 of OSTEP/PREFACE. Note number of comments in Cohort 2= 33 and Cohort 3=44. Some comments contained multiple preparedness elements.

Although the survey results indicate a positive reaction to the program, the grades in participants' first chemistry course still reflects below average performance. We show the grade in the first chemistry course because all majors required at least one chemistry course and the vast majority of participants could enroll in Chemistry 121 their first quarter. Further, beginning with Cohort 2 an attempt was made to block schedule participants in chemistry with the same instructor that taught in the summer bridge program. Table 3 shows results spread across multiple levels including remedial chemistry (101), the entire general chemistry sequence including labs (121, 122, and 123) and general chemistry for majors only (161). The small number of participants who were chemistry majors or starting beyond the first general chemistry course (i.e. in 122 or 123) performed at or above average while the large number of participants starting in the first general chemistry courses significantly underperformed. There are many possible explanations for this but it may reflect a reliance on hiring very good instructors for the summer bridge program and not developing adequate coping skills to students when they have less attentive instructors during the academic year. Or it may reflect a dislike of general chemistry among the large number of engineers in our cohorts.

Table 3. Participant grades in first chemistry course compared to course averages

Course	Number of Students	OSTEP/ PREFACE Average	Number of Students	Course Average[1]
Chemistry	3	1.7	178	2.21

101				
Chemistry 121[2]	90	2.17	2174	2.33
Chemistry 122[2]	5	2.54	383	2.08
Chemistry 123	2	2.3	315	2.21
Chemistry 161	4	2.85	92	2.77

[1]Course average data provided by the OSU Department of Chemistry
[2]The Course average data in 121 and 122 is a weighted average from multiple offered sections of each course

Retention

The most direct measure of progress toward increased STEM degree attainment is the retention of students in STEM majors. We determined retention as described in the methods section. Figure 2 shows the retention results from our 3 cohorts compared to the overall STEM population and the overall university population. Bridge program participants are retained to STEM majors at a higher rate than the overall STEM population but not at the level of the overall university population. Because of the relatively small numbers of the experimental cohorts, no significance is ascribed to the variation among cohorts. It is interesting that our program participants are retained at higher rates even though the grades in the first chemistry course are below average. This may reflect the importance of sense of belonging, groundedness, and perception of preparation to a student's persistence in a particular major.

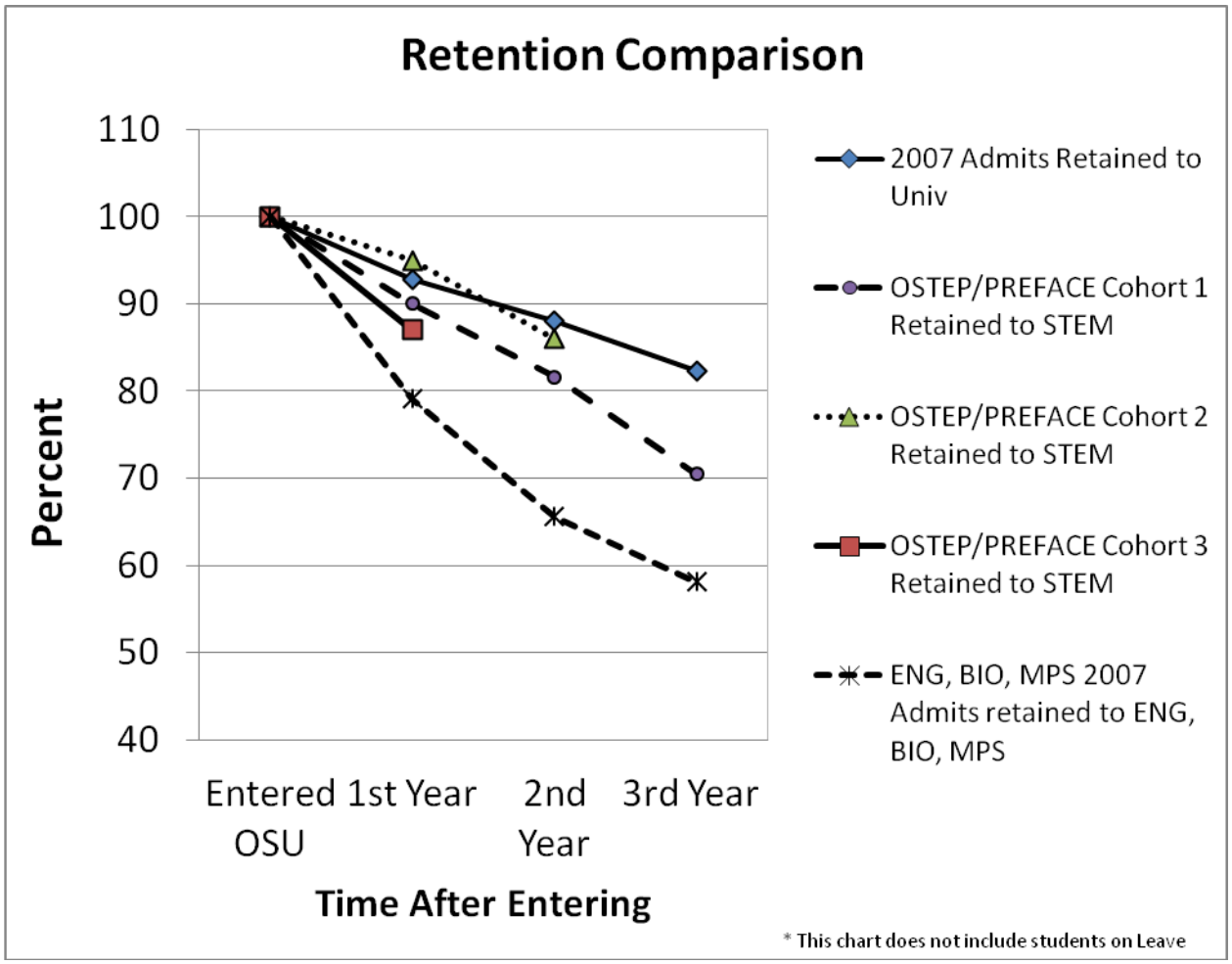

Figure 2. Retention results for OSTEP/PREFACE cohorts compared to all STEM majors and all University students.

CONCLUSION

In light of the fact that the central goal of the NSF STEP program is to increase the number of STEM graduates, and our retention data indicate that we have achieved that at Ohio State, some might consider that the end of the story. If we want to continue to improve our program and to learn more about retention in STEM programs, we need to look closely at our other results. Participation in the OSTEP/PREFACE seems to positively impact students' sense of belonging and their perceptions of their preparedness for college. Unfortunately, the participants are generally not performing as well as the general OSU population in the first chemistry class. It is interesting that this level of performance is not causing them to have lower retention at OSU than the rest of the STEM population. Could the high levels of sense of belonging and preparedness encourage students to stay in their major? Perhaps they are aware that they have the network and resources to help them improve their performance in higher level courses. The

OSTEP/PREFACE courses are designed to encourage student critical thinking and more sophisticated approaches to their work. The assumption of this approach is that students will perform better in both traditional and more inquiry-based classes, so it shouldn't matter how the chemistry classes are taught. Perhaps we need to be more extensively enriching our students in chemistry, especially those with low levels of chemistry preparation.

In the future, we will be adjusting our surveys to more explicitly address the elements of the sense of belonging and student preparedness. In addition, a longitudinal study to determine patterns of student sense of belonging to OSTEP and PREFACE and their feelings of preparedness will help us better understand the association of these variables with student retention. The longitudinal study data will also help us plan for student programming beyond the summer bridge program.

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