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The Influence of Summer Research Experiences on Community College Students' Efficacy and Pursuit of a Bachelor's Degree in Science and Engineering

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Community colleges can serve as a means to increase diversity among bachelor's degree earners in engineering given the proportional representation of African Americans, Hispanics, Native Americans, and females among community college students. However, improving the matriculation and transfer of community college students into four-year science and engineering degree programs is imperative if these groups will be represented in top-ranked four-year degree granting institutions. In order to facilitate successful matriculation and transfer it is important to expose community college students to coursework and experiences that adequately prepare them for success at a four-year institution. This paper describes the multidisciplinary summer research program for community college students in science and engineering that is offered at the University of California, Berkeley, which intends to prepare selected student participants for enrollment in a four-year institution. A mixed-method study conducted among participants in this program indicates increased self-efficacy, particularly as it relates to conducting research. This paper will present preliminary findings from the pre/post survey that was conducted and the qualitative analysis of weekly journals among the participants. Other institutions and programs can use the information shared to consider how to develop similar experiences and how to assess those programs for efficacy.

Introduction

Previous research indicates that knowledge about the admissions process as well as psychological factors impact transfer to four-year institutions among community college students and shows that satisfaction with the advising process plays an important role [1]. In considering potential psychological factors that might impact rate of transfer, self-efficacy has been identified as an important concept when considering success and retention among underrepresented groups in STEM fields. Self-efficacy has been conceptualized as four domains: mastery experience, vicarious experience, social persuasion, and physiological reaction [2, 3, 4]. Individuals receive information from each domain either through interaction with others or interaction as a result of different experiences and situations, impacting their behavior positively or negatively. Self-efficacy has been shown to impact decisions people make, how much effort they put forth, and the degree to which they persist in the face of adversity [5]. Mastery experience is viewed as having previous experience or performance with a certain task and has been shown to be one of the most influential domains [6]. Vicarious experience is defined as learning by observing others perform a task. Social persuasion refers to judgments or feedback provided by others. In each of these domains, positive experiences will boost an individual self-efficacy where negative experiences will diminish it. Physiological reaction is the fourth domain and refers to the emotional or physical state during a task. Ideally, individuals would want to be calm and composed instead of apprehensive or anxious about a given task [7, 2, 8].

Students with higher self-efficacy have been shown to persist to degree at higher rates and perform better in their course work than those with lower self-efficacy [9, 4]. Among first-year engineering students, each of the four domains of self-efficacy have been shown to influence perceptions of their performance in coursework with mastery experiences, or their performance

on course related tasks, being the most influential [5]. Self-efficacy beliefs change over the course of enrollment with vicarious experience, or comparison of personal performance to that of others, becoming more important as students progress through their coursework at the college level [10]. Female engineering students tend to have lower self-efficacy than male peers, reporting that they perceived they were not able to perform as well as their peers [10]. Self-efficacy has been shown to influence engineering students' self-regulated learning behaviors and GPA [11]. Faculty member's accessibility can influence self-efficacy, providing opportunities for faculty interaction and feedback to students can reinforce positive experiences and build students' self-efficacy beliefs across domains [11]. The curriculum and the way it is taught can also impact students self-efficacy; well-structured collaborative experiences and hands-on activities have been shown to have positive implications for self-efficacy across majority and minority students enrolled in an engineering major [12, 13].

Despite the awareness of the importance of self-efficacy, this concept has been studied in a limited sense among community college students [14]. The literature does not address what types of experiences can improve or enhance self-efficacy among college students as it relates to research, and among community college students specifically. This study addresses the gap in the literature by examining what experiences in the Transfer-to-Excellence Summer Research Program can improve the self-efficacy of community college students as it relates to research and whether this has an impact on their long-term career plans to pursue a STEM career.

Transfer-to-Excellence Research Experiences for Undergraduates Program

In 2011, the University of California, Berkeley developed the Transfer-to-Excellence Research Experiences for Undergraduates program (TTE REU), a summer research program for community college students that is catalyzed by early hands-on involvement in research projects that apply nanotechnology and biotechnology to address energy problems in a high caliber research environment. The program objectives are to: 1) provide challenging science and engineering research projects in leading edge research laboratories; 2) counsel students to prepare to transfer to competitive 4-year colleges/universities in science and engineering majors; 3) offer enrichment activities to build students' confidence to continue in science and engineering; and 4) expose students to the diversity of professional career opportunities that apply science and engineering training. This program provides community college students a nine-week research experience after being accepted into the program. This program includes on-campus housing, weekly programming that includes speakers and panels, and placement in a lab where the student works closely with a mentor to carry out their assigned tasks on the research project. The holistic program approach comprised of knowledge centered, learner centered, and community centered activities [15] is designed to develop the self-efficacy of community college students that participate, specifically as it relates to research skills.

Methodology

A mixed-methods approach using formative and summative evaluation measures was used to assess impact of the summer experience on students' self-efficacy specifically as it pertains to research. A pre-survey was administered to the students one week prior to their arrival on the Berkeley campus. The survey included questions to solicit information on: degree aspirations,

knowledge about the admissions process for enrollment at a four-year institution, confidence related to whether they thought they would be successful at a four-year institution, long-term career goals, perceptions about whether they met the criteria for admittance to and success at a four-year institution, and clarity of their academic and career goals. The survey allowed participants to rate themselves on key skills in comparison to peers including leadership, research, critical thinking, teamwork, and communication skills. A series of questions were also designed to capture students' research self-efficacy and were based on the four domains associated with this construct. Demographics about participants were also collected including income level, race, and gender. Students were also asked to name the top three institutions that they wanted to apply to and asked why they wanted to participate in the summer research experience. The post-survey asked similar questions of the participants so that gains over the summer could be measured in key areas that the program was designed to develop or enhance among participants. There were several questions that asked students about their experience over the summer and the satisfaction that they received in relation to mentoring and support from the program staff. Additional questions included an open-ended question, which inquired about what they learned over the summer.

To supplement the pre- and-post survey, the program required students to complete weekly journals. The journal entries were submitted each week to the program director. The eight topics that students wrote about were:

1) Write about how you felt going to the research lab on that first day
2) Write about a time in your internship when you felt really good about the experience you are having. How did the event that produced the good feeling come about? How did it make you feel about your mentor or other people in your lab/group? Did the experience allow you to feel more a part of the lab/group?
3) Write about how you are learning how to complete different tasks by being an intern in your lab/group.
4) Write about how something special happened to you on the job
5) Write about what you see in the people that you work with and the qualities that they have that make them successful
6) Write about how on some days the place seems like everyone is going to explode. How do people react when the workplace is really busy?
7) Write about how your internship has helped you with your career planning. Have you decided that you will follow the career you are exploring in your research project or will you probably look at other options? Is the career in reality what you expected it to be when you first thought about following it? Have you seen other career paths in the same area that you might be interested in researching? Has your research experience posed more questions than it has answered?
8) How do you feel about the new knowledge base you have developed?

Once all entries were collected for both cohorts (2012, 2013) a content analysis was conducted to determine the degree to which self-efficacy might have improved among interns over the eight week period and what experiences impacted that self-efficacy.

Analysis

Mean scores were computed for the survey data for the four questions related to self-efficacy on both the pre-test and post-test responses. Following the analysis of the survey data, the weekly journal entries for the 14 interns were analyzed using a content analysis [16]. An *a priori* coding scheme was used with the four identified self-efficacy domain areas serving as the initial codes. Following the initial coding process additional themes emerged and additional codes were assigned. Specifically, mastery experience served as the code when participants described gaining hands-on experience with a specific task they thought they would have to perform again. Vicarious experience served as the code for journal descriptions that identified learning by observing others doing a task they thought they would need to do. In the journal entries writing that identified judgments or feedback provided by others was coded as social persuasion. The fourth code was comprised of physiological reaction and was used for descriptions of emotions and physical states, including feelings of anxiety detailed in the written passages [2, 7, 8]. Writing passages were initially coded based on which theme emerged from the writing. Additional codes emerged according to what groups or experiences were influencing the self-efficacy domains, including mentors, the collaborative nature of the lab setting where the research internship was taking place, and the realization that the experiences had a real-life application. These themes were shown to have an impact on the community college students' self-efficacy as it relates to research and long-term interest in a STEM field.

Results

The sample size included 30 community college students that participated in the summer program. Ten (10) were first generation college students. Seven (7) were female and 23 were male (Table 1). In addition there was diverse racial and ethnic representation (Table 2).

Table 1. *Summary of Participation among Community College Interns* (n=30)

	N	**(%)**
Men	23	(76.7)
Women	7	(23.3)
Underrepresented minority[1]	12	(40)
Underrepresented group[2]	19	(63.3)

1. Includes Native American, Pacific Islander, Black, Hispanic; 2. Includes women of all race/ethnicities, underrepresented minorities, and veterans

Table 2. *Ethnic and Racial Representation of Community College Interns* (n=30)

	N	**(%)**
American Indian	1	(3.3)
Black or African American	3	(10)
Hispanic	6	(20)
White	12	(40)
Asian	8	(26)

Each of these participants met the minimum requirements for the summer program: 1) 3.25 grade point average or higher for science, engineering, and math courses; completed two calculus

courses; and completed three science or engineering courses, one of which has a laboratory component. In the past two summers (2012 and 2013), the TTE program hosted 30 students from 25 California community colleges. From the 2012 cohort, 12 program alumni (86%) have transferred to four-year institutions and two alumni are still enrolled in a STEM program at a community college. For the 2013 cohort, all 16 are currently enrolled in a STEM program at a community college; they have all applied to transfer to a four-year institution in fall 2013.

Quantitative Results

When considering the survey results, there were noticeable gains in the self-efficacy of the community college participants over the course of the experience. On a scale from 1 to 5 (1= well below average; 2 = below average; 3 = average; 4 = above average; and 5 = well above average), post-survey results for each of the four self-efficacy domain area were higher following the experience. Students reported they perceived they had increased opportunities to have hands-on experiences doing tasks that made them feel confident in their science and engineering ability, watched others perform tasks they themselves would need to perform, and had received positive feedback on science and engineering tasks following the summer research experience. In terms of the question related to anxiety, students did not report a significantly higher sense of anxiety following participation in the summer research program. While mean scores were compared using paired samples t-test and showed significant differences between pre and post scores, not all interns responded to all items and therefore having fewer than 30 responses on some items invalidates the t-tests that were conducted (Table 3).

Table 3. Results for Self-Efficacy Related Items from Pre- and Post-Survey (n=30)

	Pre-Survey Mean (Standard Deviation)	*Post-Survey Mean (Standard Deviation)*
I have had experiences that made me confident in my ability to perform tasks that will allow me to succeed as a student in science and engineering.	3.81 (.92)	4.63 (.492)
I have had the opportunity to watch and work with others and have seen them perform tasks that I will need to perform in order to succeed as a student in science and engineering.	3.53 (.90)	4.62(.571)
I have received positive feedback about tasks I expect I will need to perform in the future to succeed as a student in science and engineering.	3.73 (.96)	4.50 (.58)
I have experienced a lot of anxiety or nervousness about tasks that are related to success as a student in science and engineering.	3.11 (.995)	3.12 (1.24)

Qualitative Results

Qualitative analysis of the interns' journal entries was designed to explore more specifically what aspects of the students' experiences led to these changes in self-efficacy. Students provided background information about their level of self-efficacy when they started the program. Initial journal entries of the interns explained that they lacked confidence. Lower self-efficacy was attributed this to lack of academic preparation and lack of prior research experience as well as the lack of exposure that students had to peers, mentors and faculty prior to arrival at Berkeley. After meeting the people they would be working with in the lab, students realized that they had a great deal to learn in order to consider themselves on the same level as their co-workers. Given their lack of exposure and academic preparation, many students mentioned that it was difficult entering into the lab setting. This was evident in light of the fact many interns had only had exposure to their community college where many of them were top students. Other students explained that while they were apprehensive, meeting the people in the lab where they would be working helped reduce their anxiety.

Over the next several weeks through their journal entries, interns described the experiences that made them feel confident in their ability to perform tasks that allowed them to succeed as a student in science and engineering. In terms of themes that emerged, journal entries revealed that mentors played a pivotal role in gaining this confidence. In addition, students' own recognition that they were gaining new knowledge and also recognizing real-world implications of their research helped them see how they might be successful. Specifically, hands-on experiences with the lab equipment helped ease anxiety among participants and build confidence. The interns explained that interactions and experiences that they had with their mentors helped make them comfortable. For instance, having someone they respect tell them that they are not expected to know everything all at once provided them with reassurance that they could eventually learn the skills they needed to succeed in their research experience.

Self-efficacy among interns was increased when they realized that their mentor was enthusiastic about the subject that they were studying and that in many ways the interns were being provided with opportunities to interact with an expert in the field. Interns also explained that situations where they were placed in the role of a mentor helped increase their self-efficacy. The interns explained that having experiences that led them to understand the degree to which the projects had real-world implications helped them build confidence. In addition to mentors and the realization that the projects would have real world implication, interns identified experiences with new equipment as serving to build self-efficacy.

As the experience continued, interns explained that opportunities that allowed them to demonstrate new knowledge that they gained from the experience was important in helping them build self-efficacy. Despite the acknowledged insignificance of their contribution, interns still explained the experience provided them with additional confidence. Students acknowledged the powerful and unexpected results the summer experience was having on not just knowledge they were gaining but on their confidence. In fact, gaining knowledge was an important aspect of the interns' development of self-efficacy. By the end of the experience, interns acknowledged the impact of the experience on their development, and in particular their increase in self-efficacy. In addition to actually completing tasks, interns explained that they had the opportunity to watch

and work with others helped improve their self-efficacy. Interns explained that being physically situated on the campus gave them exposure to people that they could watch and also provided them with hands-on experience in a lab setting doing research.

Collaborating with their mentors was an essential part of the experience that allowed students to gain background knowledge that they were missing, and at the same time feel they were a partner in knowledge discovery. This was especially true when their mentor recognized what their intern might be missing whether it be knowledge or experience and took time to fill in the gaps. Having the sense that interns were part of a productive team helped provide interns with the sense that they were not alone. Interns explained a collaborative environment allowed them to learn from multiple individuals that they perceived as very knowledgeable, positively impacting their self-efficacy. The collaborative aspect of the labs also influenced the way the community college interns viewed research. Many noted that prior to this experience they viewed research as a solitary effort rather than as a "community, collaborative effort."

Journal entries reveal a natural progression in understanding how their experience would help them in the future. Interns acknowledged that learning from their mistakes was a valuable experience as they worked their way through hands-on applications. Having time to learn the many aspect of implementing a research project was also acknowledged as a useful experience. Interns explained that trial and error helped them learn new knowledge rapidly.

As a whole, students had no prior research experience. However, they indicated that they had prior experiences they could draw upon to help them meet different challenges. Students recognized the importance and implications that the hands-on tasks had for improving their self-efficacy. Given their initial lack of self-efficacy, receiving verbal as well as non-verbal positive feedback about the tasks they would need to perform in the future to be successful in science and engineering was important. In many cases, this positive feedback came from their assigned mentors. Verbal feedback was important to the interns and helped improve self-efficacy. Interns wrote about the amount of support they received, including the amount of positive feedback they got from their mentors. Positive feedback came in multiple forms but the most powerful seemed to be the verbal feedback from mentors and others in the lab. Interns explained that the positive feedback was rewarding because it was directly related to the hard work they were putting in during the experience. For some students getting critical feedback was part of the learning process.

Finally, experiences that allowed students to identify the anxiety that they might be feeling about tasks felt they needed to perform to be successful in science and engineering was important. Journal entries also identified new social skills that they needed to learn to be successful in a lab setting not just content knowledge and how that created anxiety for some of them. Interns also wrote that it was important that the experiences allowed them in some way to work through the anxiety and gain new perspective and confidence either by themselves or with the help of their mentor. Having someone to talk to about their anxiety was very important as explained by one intern. Interns explained that in some instances their anxiety was attributed to new social skills that they had to learn. Students struggled with the trust that lab supervisors and mentors put into them initially thinking that they were inadequate for this experience. However, as students gained confidence, the independence they were given was exciting. Given the residential nature

of this experience, another theme that emerged from the journal entries was the peer interaction that took place in the residence hall, the International House (I-House), and how that improved their self-efficacy. For the majority of interns, this was the first time living away from home and in a residence hall given their prior experience commuting from home to their respective community colleges. One student explained that having a peer group that was going through the same experiences and challenges was an important part of the summer experience.

Overall, the summer experience positively impacted the community college students' self-efficacy as it pertains to research. From the data gathered through the journal entries the interns explained how the experience gave them new confidence and led to self-discovery of what a career in research might be like as well as what would be necessary in terms of the educational path to attain that career. The experience also helped other students clarify whether this was the type of career they actually wanted, one student explained. For others, it solidified that they wanted to pursue a career path in engineering and helped to make sure they could transfer to a four-year institution and go on to graduate school. For other interns, the experience reinforced the fact that they wanted to pursue a career that would allow them to continue conducting research.

Discussion

Interns report measurable gains in engineering self-efficacy. Findings from this study provide detailed information about what types of experiences can lead to the improvement of self-efficacy among community college students, specifically as it pertains to conducting research. Across domain areas, mentoring and a collaborative environment were factors that emerged as critical to positively influencing student self-efficacy. Upon entering the experience community college students identified themselves as lacking self-efficacy to conduct research and participate in a meaningful way in the research process, either indicating they were 'not ready' or were in some way inferior to the individuals that they would be working with during the summer. Having an assigned mentor that met with them regularly to guide them through the next steps and challenges that they faced allowed the students to see how to perform different tasks that they would need to perform, ask questions and clarify what they did not understand, and reduce anxiety that they were experiencing. Results from this study document how self-efficacy of community college students majoring in STEM fields can be improved over time with consistent guidance and opportunities to demonstrate skills and knowledge they have gained in a supportive environment. While specific challenges were identified, many of which are inherent in a research setting, the students felt they gained the skills necessary to address those challenges in the future through this experience.

There are some limitations in this study. The sample used in this study was community college students who met a minimum GPA and were enrolled in a science or engineering major. Participants self-selected to participate in this research internship and may already be predisposed to developing self-efficacy in relation to conducting research. There may have been different results if students were required to engage in research as part of their course work. While the results indicate that this research experience helped this group of students enhance their self-efficacy as it relates to working in a research setting and encouraged them to transfer to

a four-year institution, if the requirements for program participation were altered so that students with a lower GPA or different majors participated it could impact the results.

Despite these limitations, this study produced some important results related to the self-efficacy of community college students. Findings identified how a hands-on, immersive research experience can positively impact self-efficacy and impact long-term career goals, including desire to transfer to four-year institutions. Our findings show that a hands-on research experience coupled with mentoring from respected individuals in the discipline and student programming can improve the self-efficacy of community college students in STEM fields. As their self-efficacy improves, students' long-term interest in STEM disciplines also grows and furthers their interest in transferring to a four-year institution so that they can pursue their desired career. Following the hands-on research experience in the labs over the course of eight weeks students explained that they participated in developing and finding solutions as part of a research team. Administrators in community colleges and four-year institutions can use these findings as they work together to design similar programs that are built specifically for community college students and offered on baccalaureate- and graduate-degree granting campuses. Through the vicarious experiences such as being exposed to and watching their mentors and other graduate students perform tasks that they anticipated they would need to perform in the future, community college students could begin to build the knowledge and skills they would need as they progress to earning a four-year degree, going on to graduate school and leading research projects of their own. The experience for these community college students was designed so that there would be adequate support in an effort to reduce anxiety or apprehension. From the journals and survey data that were collected, this experience reached that goal as students reported that while they were apprehensive initially they were able to overcome that and continue to build their self-efficacy. In many cases this was due to the verbal and non-verbal feedback of their mentors and program staff that allowed students to feel they played an important role and were making valuable contributions.

Overall this study provides a better understanding of what experiences can positively impact the self-efficacy of community college students in STEM fields. Results also indicate that improved self-efficacy as it relates to research in an academic environment is related to the long-term career goals and academic aspirations of these students.

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