AC 2008-2943: A NEED FOR SYSTEMS-ORIENTED OUTREACH: LESSONS FROM A FAILED, 1-DIMENSIONAL APPROACH

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Abstract

To increase the probability of college-level academic resilience of Hispanic high-school students, we initiated an in-school tutoring and mentoring program. We provided 15 classroom laptops and free access to a multi-lingual web-based math tutoring site to two test cohorts of high-school juniors totaling 56 students. The weekly mentoring was provided by college-aged students (Hispanic and other descent) and an Hispanic adult engineer. The research question that we were addressing was: Can web-based math tutorials in Spanish engender greater confidence in math and interest in higher education within a Hispanic high-school community? At the end of six months, the pre- and post-tests of the test cohorts and quasi-control groups (128 students) revealed no significant differences in students' interest in math, interest in college, or confidence in math. This particular course consisted of students who had failed math in the previous year. Socioeconomic demographic data of the test and control cohorts was analyzed also, finding no significant differences between the groups. In other words, it does not appear that the web-tutorials and weekly tutoring with a mentor of similar ethnicity had a measurable impact over the course of the study. To gain further insight, students in the test cohort also generated "user profiles" of a high-school students, listing their needs if they were to go to college along with their concerns. The resulting profiles, focusing on a range of social factors related to learning motivation, underscore the need for outreach activities to incorporate a systems approach, simultaneously leveraging the multitude of factors that contribute to academic resilience. In this paper, we present the failed 1-dimensional approach, the data from the "user profiles", and a guidelines for engineering faculty to enable more effective outreach.

Introduction

This is a paper about failure...the failure of a well-intentioned group of engineering faculty to recognize the need for non-engineering perspectives to solve a socially-related "problem." The problem that we were attempting to solve was the problem of low retention of Hispanic students in our engineering program. Over the course of about 15 years, we observed a high rate attrition among Hispanic students with a common theme of difficulty in mathematics. We note that students in our program are predominantly white (~80%) or of asian descent (~10%) with a small proportion of HIspanic students (~10%). Over the course of 15 years, this constitutions approximately 35 students. While our program is too small to make statistical inferences regarding this observed trend, the issue of academic risk of underrepresented students in general has been studied [1] as well as the issue of resilience in mathematics for underrepresented students [2]. Engineering programs traditionally experience attrition rates from the freshmen year to graduation ranging from ~45% to 70% {Fortenberry, 2007 #201, but our observations over time told us that we were losing Hispanic students at a disproportionately high rate. In retrospect, students who left our program often leave due to difficulty in calculus, which largely functions as a "weeder" course, weeding our many who do perform to the courses' standards.

Our research hypotheses were that allowing students access to a web-based, multilingual tutoring program for mathematics would improve students confidence in mathematics and interest in pursuing a college. The following paragraphs describe how we tested our hypothesis, the outcome and recommendations for future outreach programs. We begin by describing the institutional setting in which the study took place.

The institutional setting

The site of the setting was a high school located in California. The high school is approximately 65% Hispanic in student population. Overall, the families represent a middle-class socio-economic demographic. Few, if any students, were families coming from a migrant-working population. The students involved in the study were sophomores in a high school algebra course, taught by a total of three different instructors, none of whom who are of Hispanic descent. The test groups were two sections of algebra, one with 36 students and another with 32 students. The course met daily for one hour. These particular students were taking the algebra course for the second time. The faculty teaching these students was also involved in the creation of the web-based tutorials with a third-party company. The other sections (4) were taught by faculty members who were not involved in the study. There were no interventions for these other sections totaling 128 students and they served as the quasi-control comparison group.

Research methods to test the hypothesis

Prior to the beginning of the study, student were asked to compete a survey. The survey included information about the confidentiality of the responses, places to put a student identification number for post-test tracking, questions regarding their enjoyment of math, their beliefs about the difficulty of math, future career choices and family education level. A list of the questions are shown in Table I. The questions regarding family education were meant to be used as a factor in the analysis. The program was initiated in September 2006 and ended in May 2007. During the course of this time, a liaison who was Hispanic descent and a lecturer in an engineering program at a local university met weekly with the students to tutor them, mentor them and build relationship. The two test sections were given 15 computer laptops loaded with the interactive tutorial software and given access to this equipment at any time during their week by their course instructor. These laptops had the capability of tablet-functionality, with users able to use an electronic pen for input. No other software was loaded on these laptops, to eliminate the non-course use of the computers. While the software is normally a web-based tutorial program, the computers did not have internet access to minimize non-authorized use of the computers. The software loaded on the computers had all the functionality of the web-based tools.

The software that was used was an interactive streaming software that allowed students to watch problems worked out as if an instructor were writing on the board and included audio along with the video. The were multiple examples in remedial algebra, all the way up through advanced high-school algebra. The content of the computer modules was consistent with high school

requirements for the course did not deviate from the original content of the course prior to the incorporation of the web-based tool.

During the course of the study, the liaison would occasionally bring college-aged students (some of Hispanic descent, some not) with him to interact with the students. At the end of six months, student were given the same initial survey. The pre- and post- tests were analyzed using a paired t-test for the individual items, using "teacher," and "highest family level" as blocking factors in the analysis.

Table I. A list of the survey questions

3. I enjoy math (circle one): YES NO NOT SURE
4. I believe that math is a difficult subject to learn (circle one): YES NO NOT SURE
5. When I leave high school, I plan to have a job the doesn't require math:YES NO NOT SURE
6. I am planning on going to college: YES NO NOT SURE YET
7. I believe I am able to learn math, even when it's difficult: YES NO NOT SURE YET
8. I am a little nervous about learning math: YES NO NOT SURE YET
9. Math is valuable in the real world: YES NO NOT SURE YET
10. My family is good at math: YES NO
11. The highest level of school that someone in my family has completed is (circle one): HIGH SCHOOL, 2-year college degree, 4-year college degree, master's degree, Ph.D Professional degree (like M.D. or J.D.)
12. I am thinking about pursuing a career, like engineering, that uses math and science: YES NO MAYBE
13. If my math teacher doesn't show me, I can learn math on my own: YES NO NOT SURE

Results

One unexpected result was that we lost about a third of the data responses due to an inability to match pre- and post-test student identification numbers. Even in the remaining data, we had to interpret some of of the student identification numbers in order to match pre- and post-responses. Another unexpected result was that there were no statistically significant changes at a level of $p=0.5$ in any of the response items after the six month period. Incidentally, we also looked for significant differences in family education across the sections and found none. P-values exceeded $p=.10$ in all cases, with many of the p-values being closer to $p=.30$ and larger and some showing unreasonable changes (e.g., a lower level of family education) in the post-test.

In his role as mentor, the liaison discovered that many of the students were struggling with issues entirely unrelated to mathematics. Many revolved around social issues. We ran a session in which we asked the students to brainstorm their needs and concerns revolving around attending

college. Eleven groups ranging from 3-6 students developed composite sketches that indicated their needs and concerns. These images revealed a number of themes that were unanticipated by the research designers. Figure 1 shows examples of these needs.

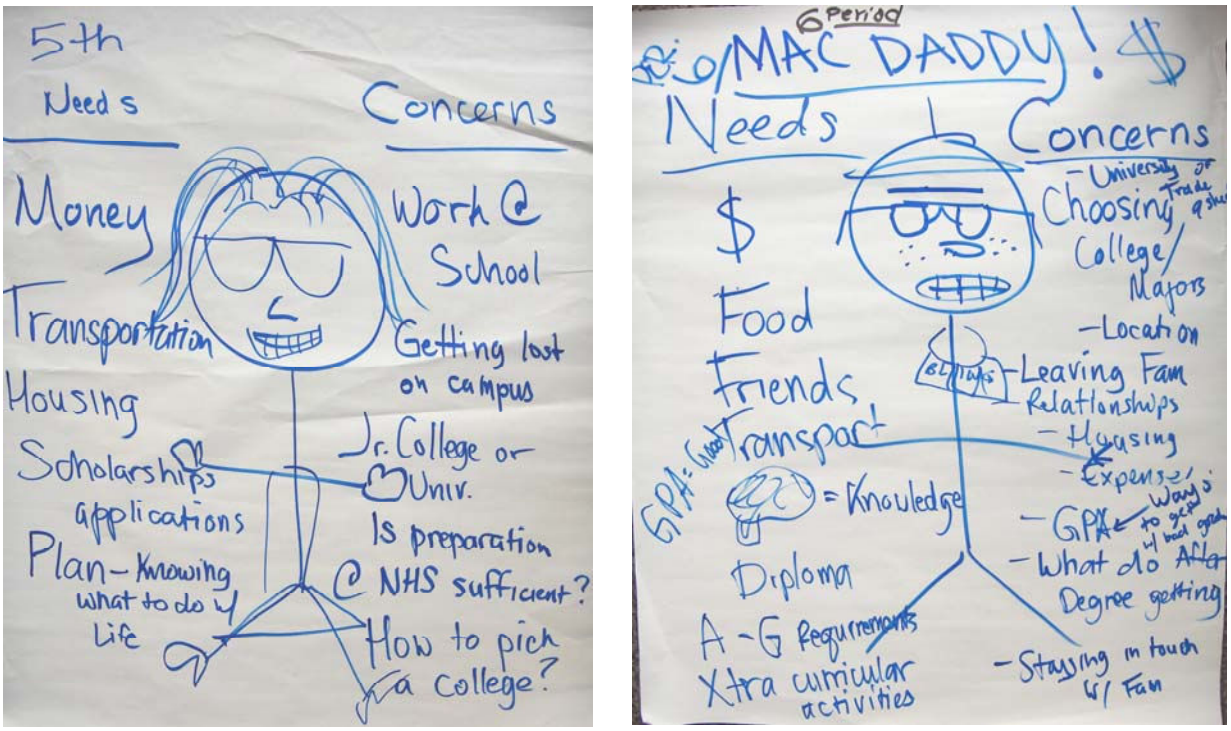

Figure 1. Examples of the "Needs and Concerns" generated the students in the test groups.

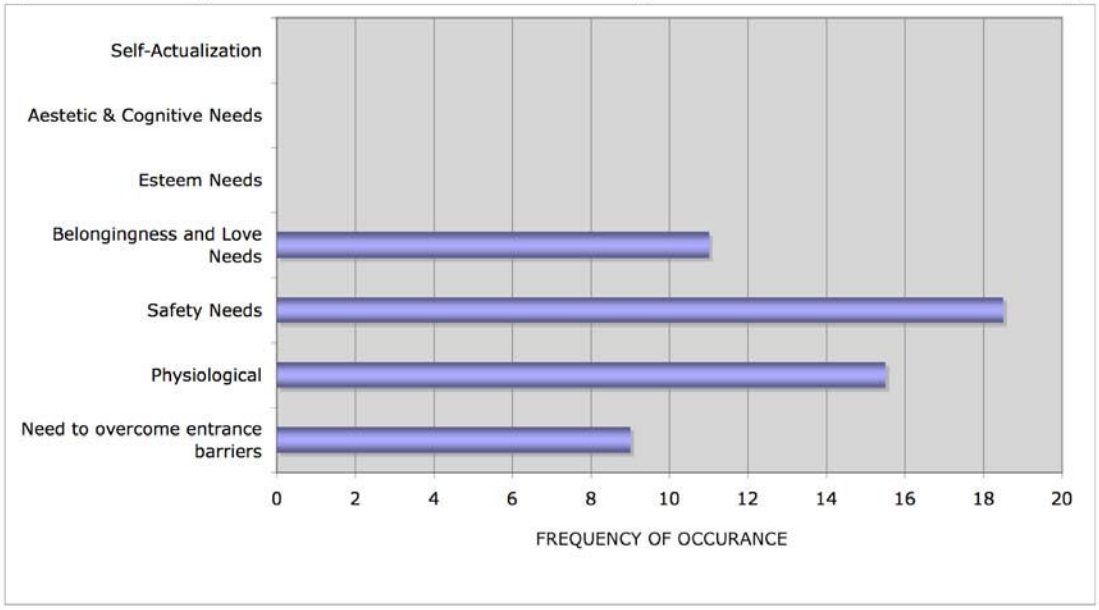

Figure 2. Frequency of the type of needs expressed by groups. There were 11 groups.

The needs and concerns were categorized into groups based on whether the concern related to

overcoming the barriers to entering college (e.g., obtaining an diploma, completing high-school requirements, high SAT scores) or whether they related to things needed while at college (e.g., guidance, friends, housing). All groups indicated "money" as a need. This was interpreted as a need for money as a means to obtaining food, shelter, school supplies, tuition. We used Maslow's Hierarchy of Human Needs {Maslow, 1943 #140}, pictured in Figure 3, as a way to categorize the needs. Since the meaning of "money" or "scholarships" was somewhat ambiguous, we split these responses equally into the "Physiological needs" and "Safety needs" categories. As shown, the primary concerned revolved around overcoming the barriers to college and the basic needs (physiological, safety, love and belonging). No students mentioned any of the higher-order needs, such as chosing a major that was interesting to them or contributing to society.

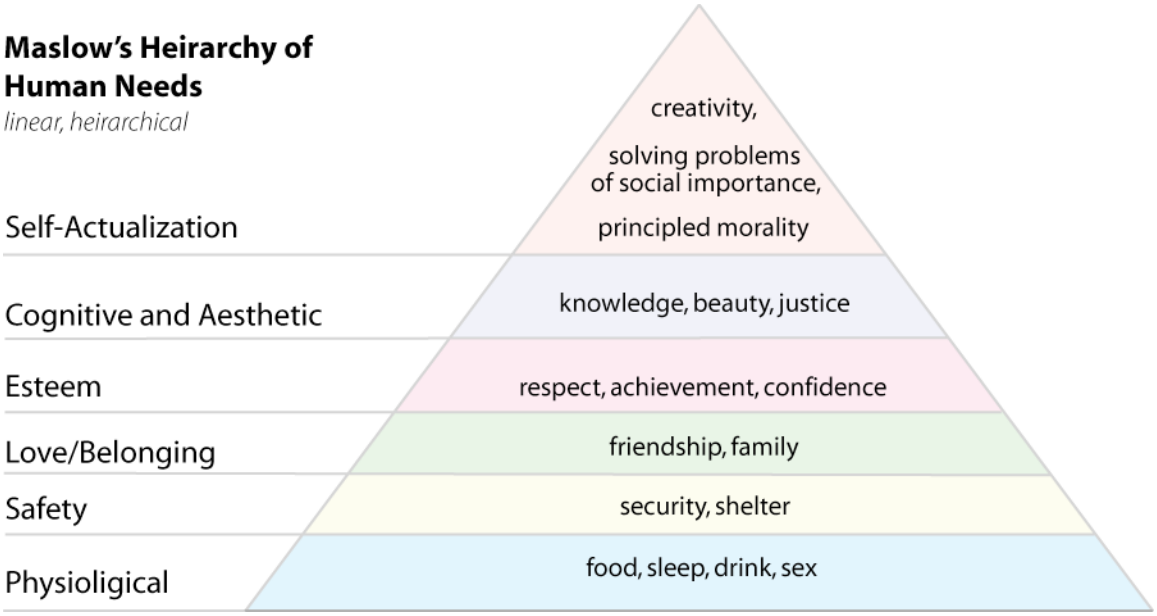

Figure 3. Maslow's Hierarchy of Human Needs.

Discussion

The various aberrations in the post-test results caused the researchers to question the integrity of the data. However, a bigger problem, we feel, was that we did not involve the appropriate stakeholders in the design of the experience. While we consulted with the high-school faculty member, we did not get input from a range of individuals from the Hispanic community. For example, it was brought to our attention after the survey was initially administered, that the question regarding the highest-level of family education did not include an appropriate range of responses (i.e., some parents may not have participated in the U.S. public education system). In essence, we failed to follow the guidelines for questionnaire, such as piloting the survey on a group similar to the target group [3]. An expert in Latino-American studies could have enabled us to more effectively meet our goal of "assisting" the students.

During the later half of the study, we learned that we were actually trying to assess dimensions of student beliefs about learning that had been studied extensively in educational psychology.

For example, the idea that one is capable of achieving their goals is a construct called self-efficacy for which there have been reliable and validated survey instruments already developed, such as the Motivated Strategies for Learning Questionnaire [4]. We were also trying to access students beliefs about learning called epistemological beliefs, which have also been extensively studied[5] [6] [7] [8]. Reliable instruments have been developed for assessing epistemological beliefs [9]. If we had involved a specialist in educational psychology at the outset, our hypothesis and methods would have been far more effective.

According to the work of Borman and Overman, academic resilience for underrepresented students is assisted through strong, supportive faculty relationships [2]. The intent of the liaison was to fulfill that role from the Hispanic perspective. However, we learned that once a week was not frequent enough to make a measurable difference. We note that there was a strong bond formed with the students by the liaison. Through conversations that he had with the students, we discovered that many questioned the value of college (few considered engineering as an option). In the course of the study, we also questioned the value of "selling" the idea of an engineering major to those who wanted careers as firefighters, hair stylists, mechanics. We have not resolved this question within ourselves, but feel it is an important new awareness. It points to the problem of assuming shared values and beliefs (e.g., "a college education will help you through life.").

In reference to the needs and concerns that the groups developed, it is not surprising that these very young adults (high-school sophomores) were very focused on basic needs and questions of finishing high school or getting into college. Maslow's theory is that these "lower order" needs must be met in large part before one pursues the higher order needs. What is surprising is that we did not recognize the broader set of issues that students would be struggling with in their decisions to attend college. Our initial approach was essentially a one-dimensional approach: targeting better mathematics preparation. We neglected to address the myriad of social issues or other factors that have been shown to influence a learners' motivation to engage in learning [10] [11] [12] [13].

Lessons Learned

This was a program designed by engineers only. Although our initial outreach efforts to a heavily Hispanic high-school group were well-intentioned, we failed to make a measurable difference in their attitudes about math or attending college. Some of this failure was related to poor measurement practices. However, the root cause was the failure to consult experts with the relevant expertise. In retrospect, it seems obvious that we should have done so at the outset. However, we also admit that we have witnessed 15 years of outreach programs that are designed in the absence of the relevant stakeholders and experts. In order for the engineering educational community (including ourselves) to make significant progress toward attracting and retaining underrepresented students, we must collaborate with colleagues who have the relevant expertise. We also must take a systems view and pay attention to the multiple factors that influence students resilience. While these results may not be generalizable to larger populations of

Hispanic students, the fact that students are mostly concerned about their basic needs may suggest that programs consider tailoring marketing campaigns for engineering to different demographic groups. Before doing so, however, it is important to consider the more fundamental question of "Why will an engineering degree be valuable?" to any of our potential students (underrepresented or otherwise). Engineering faculty have dedicated a majority of their lives to the engineering profession, but finding what best resonates with each individual students' value system is perhaps more important than the preservation and growth of our profession for its own sake.

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