AC 2009-2185: ASSESSING STUDENT ATTITUDES AND INTEREST IN PHYSICS AND ENGINEERING AS A RESULT OF THE PHYSICS OF CELL PHONES AND WIRELESS COMMUNICATIONS CURRICULUM

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Introduction

For over twenty years the College of Engineering & Science at the University of Detroit Mercy has offered a summer out-reach program for local high school students. The UNinitiates Introduction to Engineering (UNITE) program is designed to resemble a university freshman engineering curriculum. The goal is to introduce students to the subjects and skills necessary to succeed as an engineering student. Classes involve hands-on activities emphasizing team work. Students take five classes daily - Persuasive Speaking, Computers, Mathematics, Physics, and College Writing - all taught by University professors. All UNITE students are registered as University students and receive an official grade in each of their five classes. Students can earn two college credits per course provided they earn at least a C. Applicants to the program are required to have at least a 2.40 GPA, no grades below a C- and good citizenship/conduct marks. Those students who are considered are invited to the interview phase. At that point, a personal essay and teacher letter of recommendation must be submitted. The UNITE program is sponsored by the Junior Engineering and Technical Society (JETS) with support from the U.S. Army Research Office. Of the UNITE graduates, 79% are enrolled in college nationwide.[1]

For the past three years we have used the Physics of Cell Phones and Wireless Communications[2], as part of the UNITE program at the University. The curriculum was developed by high school physics teachers to comply with state curriculum standards and guidelines in the natural sciences. This class replaced a traditional introductory college mechanics laboratory curriculum, which was not inquiry-based and provided only limited opportunities for students to construct their own knowledge by performing open-ended activities.

Research into physics education provides insight for the design of innovative curricula and pedagogy.[3] The learning environments that are able to demonstrate the highest rates of student achievement, as measured by standardized examinations, involve some form of what is commonly called *interactive engagement*. Hake defines, ‘‘Interactive Engagement’’ (IE) *methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors*,…”[4] Innovative pedagogy such as collaborative learning, peer instruction, tutorials, and computer based instruction are now commonly used to increase student achievement (a comprehensive review of the literature can be found in reference 2). Students bring their personal histories with them to class, and it has been shown that their expectations play a critical role in the outcome of a physics course.[5] Similarly, it has been shown (for example, see Reference 5 and references therein) that student attitudes towards a Physics course they have completed influence their future engagement with science and engineering disciplines and subsequent career choices.

In this paper, we discuss student attitudes and interest in science and engineering arising from their participation in the Physics of Cell Phones class at the University of Detroit Mercy. Our

assessment of student attitudes is based on two instruments: One is a pre-post survey administered to all students who attended the UNITE program during the summer of 2008 and the other is an online Flashlight survey accessible to all students who participated in the program over the past three years. Our rationale for implementing these surveys was to determine the effectiveness of this interactive-engagement curriculum in (a) motivating students to take physics classes in high school, (b) motivating students to take advanced placement (AP) courses in high school, and (c) in considering their attitudes towards careers in science or engineering. Results from these surveys are presented and analyzed.

Student Demographics

The population of the UNITE program at the University of Detroit Mercy serves the school districts in the Metropolitan Detroit area. Students attending the program represent over twenty five local high schools. Typically the program receives about 75 applications per year. Students are selected based on GPA, teacher recommendations and faculty interviews. Approximately, 40 students successfully complete the program every year. The program is particularly targeted towards students from under-represented groups within these districts. The percentage of African-American and female students enrolled in the program has approximated 90 percent and 50 percent respectively, over the years. As such, the population would be well served if we could increase the likelihood that students completing this program go on to successfully graduate from college with a science or engineering degree.

Curriculum

The content of Physics of Cell Phones and Wireless Communications was designed to be covered in a high school physics classroom over a four week period. The curriculum is relatively inexpensive and traditional laboratories have much of the necessary additional support equipment. The curriculum consists of 24 student-centered activities in support of 30 well-articulated learning outcomes. The activities are broadly grouped in 3 categories: the properties of sound and light waves, analog and digital signals and their transmission, and cellular telephone network operations. The activities are in the form of a role-playing game where students model cell connections and handoffs. The students do much of the work at their own pace while some sets of activities need to be coordinated by splitting the class into groups. Each student receives a reusable instruction manual and a set of laboratory notes to be completed during class. The network operations portion of the curriculum is particularly interesting since it provides hands-on, interactive activities to simulate Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), and Global Systems Mobile (GSM) methods. Details of the curriculum and activities have been described previously.[6]

Survey Results

Students participating in the Summer 2008 UNITE program were asked to complete pre- and post surveys regarding their attitudes toward the program. They were asked to respond to 21 statements and their responses were rated on a five-point Likert scale (Strongly Agree = 5 to Strongly Disagree = 1). Table 1 shows a summary of the eight questions that were related to the physics course and their attitudes towards math, science and engineering as a result of

completing the program. Questions regarding the broader program are not reproduced below. There were a total of 44 students in the 2008 cohort, which was also the total number of respondents for the survey. This was the first year the pre- and post-surveys were administered to the students.

No.	UNITE 2008 Pre-Post Summary	PRE	POST
1.	I am confident I can earn at least a B in a physics class.	3.93	4.34
2.	I am confident in my ability to use science lab equipment.	4.33	4.27
3.	I am good at science.	4.18	4.42
4.	I am interested in taking physics classes in high school.	4.07	4.23
5.	***As an adult, I will get a better job if I take math, science and computer classes.***	***4.43***	***4.77***
6.	***People who are good in math and science are cool.***	***3.25***	***3.84***
7.	I can picture myself taking advanced math and science classes in school.	4.00	4.18
8.	***I want to work in an engineering or science field.***	***3.91***	***4.16***

Table 1. Summary of the questions and student responses for the 44 students in the 2008 cohort.

In January 2009, all students who successfully completed the UNITE program over the past three years were asked to complete a brief online Flashlight survey. In this case, students were asked to respond to statements that were specific to the Physics of Cell Phones course, as well as its possible influence on their high school education. In addition, we repeated three questions from the 2008 Program survey in order to gauge general student attitudes towards science, math and engineering. Responses were rated on the same Likert scale as the earlier survey. The response rate for this survey was somewhat low, with 19 respondents essentially evenly distributed between males and females and among all three cohorts. A summary of these results is presented in Table 2. Questions that were identical between the two surveys are identified in bold italic fonts in both tables.

No.	UNITE Online Survey	POST
1.	I was able to learn something useful about cell phones from the class.	4.53
2.	The level of difficulty of the class was just right for me.	4.21
3.	This class will encourage me to take physics classes in High School.	4.16
4.	Taking this class will make it more likely that I will take Advanced Placement classes in High School.	4.05
5.	Physics of Cell Phones and Wireless Communications was an interesting class and should continue to be taught.	4.63
6.	***As an adult, I will get a better job if I take math, science or computer classes.***	***4.63***
7.	***People who are good in math and science are cool.***	***4.16***
8.	***I want to work in an engineering or science field.***	***4.26***

Table 2. Summary of questions and responses for the 19 students who completed the survey.

Analysis of Results

A thorough analysis of the above survey results was complicated by two factors. We discuss each issue, and its resolution, separately in what follows. Our first statistical challenge was that we did not have the complete data set of individual responses for the 44 students in the 2008 cohort. Consequently, we were not able to run a paired t-test analysis for each of the eight questions to determine whether the differences in pre-program and post-program means for that question were statistically significant or not. Therefore, we decided to analyze if their responses to all eight questions signified an *overall* change in attitude towards math, science and engineering. This paired t-test revealed that, in fact, the overall change in student attitudes was significant, $t = 3.89$ ($df = 7$), $p < 0.05$ (two-tailed).

Our second statistical challenge was that the sample size for the online survey was not sufficient to make meaningful quantitative comparisons. However, considering the consistency of responses on identical questions from the two surveys, we think it appropriate to make some qualitative observations based on survey results. Both surveys show that students within the program have a clear interest in a career in a science or engineering field. They also recognize the importance of taking science and engineering classes in high school to help them increase their prospects for a better job. Despite the low statistics, the fact that many respondents in the second survey had completed the UNITE program two or three summers ago raises an interesting question about the source of their continued interest in science and engineering. We hope, through continuing research, to identify the role played by courses such as the Physics of Cell Phones in helping sustain this interest.

A more significant result comes from student responses to Question 4 on the second survey. Nearly three-quarters of the respondents either "strongly agreed" or "agreed" that taking the Physics course would encourage them to take AP classes in high school. None of the students indicated disagreement with this statement. This result is important for two reasons: First, more than 90 percent of colleges and universities accept AP exam grades to grant university course credit or for appropriate placement.[7] Selective colleges and universities use AP course grades and, to some extent, AP exam grades in making selection decisions.[8] Dougherty et. al., "conclude that the percent of a school's students who take and pass AP exams is the best AP-related indicator of whether the school is preparing increasing percentages of its students to graduate from college."[9] From this perspective, it seems apparent that one useful goal of a high school outreach program, such as UNITE, should be to increase participation in AP courses.

College Board data also indicate that under-represented minorities and low-income students have significantly lower rates of scoring a 3 and above on AP exams (data available in reference 7). Yet, as Adelman indicates, "Advanced Placement course taking is more strongly correlated with bachelor's degree completion than it is with college access."[10] For the UNITE program at the University of Detroit Mercy, with its high percentage of minority and female participants, courses such as the Physics of Cell Phones could have an impact not only in increasing the participation of these students in AP courses, but possibly also on their retention rates in college. While the latter conclusion is somewhat speculative, the importance of this issue for engineering disciplines cannot be underestimated, and calls for further inquiry.

Conclusion

Wireless communication devices provide a valuable context in which to teach important concepts in physics and engineering. Our findings indicate that, when included as part of a high school outreach program that targets under-represented minorities and women, innovative curricula based on interactive engagement pedagogies could motivate students to take physics and AP courses during their high school years. In turn, this could lead to greater college access and graduation rates for these students. Our goals for future work include a continuation of the pre-post survey that was conducted for the 2008 cohort. A comparison of data across multiple years could help increase the effectiveness of the overall program. In addition, creating separate categories of questions that each target one specific aspect of student attitudes, such as their ability to use science lab equipment or their interest in a science or engineering career, would provide more useful information on the strengths and weaknesses of the program.

One of the significant challenges to increasing the response rates on our online survey was the fact that we did not have email addresses or other means of communicating electronically with students in the program. While every student was provided with a university email account, many no longer made use of that account after they completed the program. Consequently, we had to resort to mailing letters to all the students, providing them with the website address for the online survey. One of the initiatives we are considering for the Summer 2009 program is to encourage the students to establish an online cohort through the use of social networking sites like Myspace or Facebook. We hope that this will facilitate continuing communication between the students themselves, as well as with the UNITE program at the university.

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