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Encouraging and Motivating Minority Engineering Students Through Summer Research Initiative

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Abstract

The 21st Century ushered in a new era of globalization with accelerated rate of technological developments demanding a work force highly trained in STEM (Science, Technology, Engineering and Mathematics) fields. The current US administration has recognized this challenge by making education a priority and focusing particularly on the restoration of America's leadership in Higher Education with special emphasis on the role played by Community Colleges. We have been charged with preparing a well-trained student population in the STEM fields to meet these challenges and stay competitive in the global markets. Consequently, innovative educational programs must begin at an early stage of students' education with the theoretical and practical applications needed to become front-runners in this competitive world. There is an imperative to introduce students to a research environment where students can experience career relevance motivating them to continue pursuing these fields. By conducting research through internships with faculty members, students will be empowered to develop skills and will be motivated to succeed within STEM areas. Therefore, the Summer Internship Initiative will narrow the gap between theory and application by making the theory relevant to existing research projects and making the learning process exciting and interactive for

students, thus increasing retention in the STEM areas. Hostos Community College of CUNY *has* partnered with senior colleges in CUNY and the Goddard Institute of Space Studies (“GISS”) in New York City to expand the educational horizon of our students, enabling them to compete and win in global markets. The latter is possible through collaborative research initiatives that develop and improve critical thinking and creativity skills, hands-on, team oriented, and interdisciplinary learning via collaborative research projects.

Keywords: Engineering, Education, Summer Research, Motivating, Minority

Introduction: So what is “motivation”? The Wikipedia dictionary defines motivation in the following way (wikipedia, 2010):

“*Motivation is a psychological feature that arouses an organism to act towards a desired goal and elicits, controls, and sustains certain goal-directed behaviors. It can be considered a driving force; a psychological one that compels or reinforces an action toward a desired goal. For example, hunger is a motivation that elicits a desire to eat. Motivation is the purpose or psychological cause of an action*.”

How important is motivation? The literature is filled with answers and we will not discuss this in detail since it is not the purpose of the current article. We will simply mention an example from the book “Educational Psychology: Developing Learners” by Jeanne Ellis Ormrod (Ormrod, 2003) where some key motivators are listed, including:

- Provide direction
- Increase energy and overall effort
- Increase initiative and drive
- Enhance cognitive processing abilities
- Highlight reinforcing consequences
- Improve overall performance

The above criteria are important for all students, but particularly important for students majoring in STEM education. We need to motivate our engineering students so they can be successful in their educational and occupational lives. As we see from many years of experience of teaching Mathematics and other STEM related disciplines that motivating, by nature, is not an easy task. When it comes to STEM education, this becomes an even more difficult task. This, in part, probably because in a STEM related discipline, the students are required to give more continuous attention and effort to understand the difficult concepts. On top of this, the groups of students that we are working on are, for most part, full time workers with family responsibilities. Most of them are minority students and have many other social, economic, and political problems to deal with in their personal and professional lives. This is especially true for students in the evening classes, who after a long day of work, have difficulty concentrating in class and, even when they understand the lecture, difficulty retaining the knowledge and manipulating it in the future (especially during an exam). In fact, one student from our calculus I class made the following comment:

"It is really difficult for me to keep my eyes open, and keeping concentration after the first 20 minutes of the lecture is almost impossible for me. Gradually, as the semester goes on, the classroom becomes my bedroom."

The comment above aligns well with research findings. McKeachie points out the following:

In a typical 50-minute lecture class, students retain 70% of what is conveyed in the first 10 minutes but only 20% from the last 10 minutes. If we really want to get our message across, we need to orchestrate "the material" in a multi-faceted way across the range of student learning style. (McKeachie, 1994)

A Description of Our College:

At this point a short description of our college is necessary to understand our student body. The City University of New York (CUNY) is a leading urban public university serving more than 480,000 students with 23 campuses in New York City. CUNY has a diverse body of students, like most urban universities in the US. Hostos Community College (HCC) is the smallest campus within the CUNY system with more than 6,000 students. HCC is located at the heart of the South Bronx and takes pride in its historical role in educating students from diverse ethnic, racial, cultural and linguistic backgrounds, particularly Hispanics and African Americans. Hostos community college is a “Hispanic Serving Institution (HIS)”. Usually, in a typical class, 60% of the students are Hispanic, 30% are Black and 10% are from other ethnicities (Assessment, Fall 2012). So, how to teach such a diverse body of students?

Description of Our Project:

A single method of teaching cannot be appropriate for all the students. Susan and Linda described this fact as follows:

By now it is axiomatic to point out that student bodies are increasingly diverse, not only in terms of ethnicity and gender, but also in terms of age, nationality, cultural background, etc. This diversity can affect classroom settings in many ways, including the diversity of learning styles. (Susan & Linda, 1998).

They point out that African-American and Mexican-American students are more likely to prefer working with others to achieve common goals (Banks, 1988). The literature shows that the metaphor of dialogue is more appropriate for the working styles of these student bodies in that it emphasizes the interactive, cooperative, relational aspects of teaching and learning (Tiberius, 1986). As a result, we need to rethink our traditional way of teaching, where students are thought of as empty bags which we fill with as much knowledge as quickly as possible. On the other hand, we also need to think more about how much of this knowledge the students, in fact, retain in the long run.

How can we motivate and encourage such groups of students? The answer is not simple, of course. In this article, we describe how hands on experience side by side with theory helps students stay focused, retain, and apply knowledge. This is not a secret and it is well known throughout literature that applying theory motivates students in many ways. Since we have been charged with preparing a well-trained student population in the STEM fields to meet new challenges and stay competitive in the global markets, we need to rethink the way we teach our students. This is even more true for a "Hispanic Serving Institution" where the majority of the students belong to minority groups, and whose styles and situations differ from "traditional" college and university student populations.

To support these students innovative educational programs must begin at early stages of their education, with the theoretical and practical applications needed to help them become front-runners in this competitive world. It is imperative to introduce students to a research environment where they can experience career relevance as a motivator to continue pursuing these fields. By conducting research as part of internships with faculty members, students will be empowered to develop skills and will be motivated to succeed within STEM areas (Bailey & Alfonso, 2005). Therefore, the "Summer Research Initiative" will narrow the gap between theory and application by making the theory relevant to existing research projects making the learning process exciting and interactive for students, thus increasing retention in the STEM areas (Engle & Tinto, 2008).

We will give an example right way. In a lecture of calculus I, for the topic of optimization, we bring cardboard, scissors, bowls and water to demonstrate some of the optimization problems. One such problem is to find out the size of the square that needs to be cut out from each corner of a given piece of cardboard so that the box made from this process has the maximum volume. All students were given cardboard and scissors and they all had a hands-on demonstration of the problem. It seems that majority of the students understood the problem right away, and quite a few already knew how to attack the problem. This was an eye opening experience for us as teachers. A couple of students actually came to us and said (This is not from a survey but an off-the-cuff remarks after class):

"This is probably the first class in the semester where they did not fall asleep. Why not every class be like this one?"

As teachers, we have the responsibility to "finish the syllabus". Since a majority of the students are engineering students, they need to take all the calculus sequence (from calculus I to calculus IV). Thus, it is important for us to finish the syllabus for calculus I. So there is always a struggle between finishing the syllabus on time and doing hands-on experience in classes, which takes time and effort on the parts of both instructors and students. So, we need to choose a middle path.

The summer research presented us with a new opportunity. In the summer research program we do not have the pressure of finishing a syllabus, and we can work more freely and independently. Of course, on the flip side of the coin, we can only reach a very limited number of students in such a way. However, the students that we reached have had long term, fruitful motivators to continue in their STEM fields. This is evident from the next year retention data where all the students who participated in the "Summer Research Initiative" either graduated or continue their study in the same engineering major. Although, we need to keep in mind that this data is only collected for one year and we stand very early stages of this experiment to definitely make a scientific decision. We need repeat this "Summer Research Initiative" for at least a couple of more years to definitely see the effect.

Continue the Description of the Project:

We will continue describing the method of our approach in this project. What the students were learning in theory in the spring term, they were applying in hands-on experiences in this summer research initiative. A few examples of connections between topics in theory and experiment for the summer research initiative are shown in the following table:

Theory in the spring term	Corresponding research topic in the summer research initiative
Matrix multiplication (linear algebra)	Image compression
Geometry of 2D (college algebra)	Image processing
Optimization and derivative (calculus)	Application in industry (maximizing profit, workers input etc.)
Heat equation (differential equation)	Hands-on experience with heat equation with computer model
Integral calculus (calculus II and III)	Use of "Mathematics" software to solve real world problems in integral calculus.

For this kind of summer research initiative, we need collaboration from different colleges and agencies. In fact, Hostos Community College of CUNY has partnered with senior colleges in CUNY and the Goddard Institute of Space Studies “GISS” in New York City to expand the educational horizons of our students and enable them to compete and win in global markets. This is possible through collaborative research initiatives that develop and improve critical thinking and creative skills, hands-on, team oriented, and interdisciplinary learning via collaborative research projects.

The major goal of this summer research initiative is to introduce minority engineering students to research environments that include team settings. For the Hostos Community College team in the summer of 2012 and 2013, we have two undergraduate students and two high school students participating, and two high school teachers and one faculty member directing the team. There are fourteen of such teams across the CUNY campuses each year. This is an ongoing project and as time goes on, we will be able to reach more and more students.

Examples of Hands-on-Experience:

Some of the hands on experience that was done in the summer research included the following:

1. Students took digital photos and plotted graphs of the space each photo takes when saved in the computer. They compared different places the photos were taken versus different times of the day.

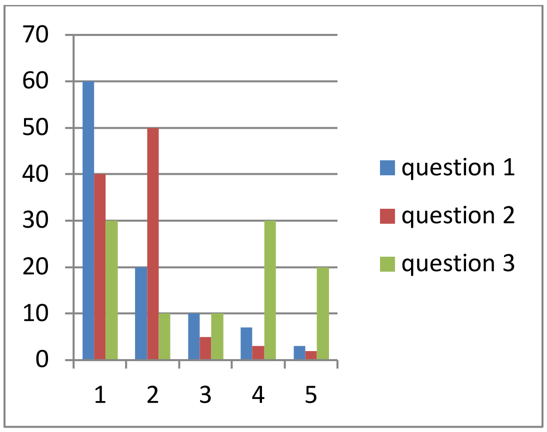
2. They used different kinds of image compression techniques, including “singular value decomposition,” JPEG compression, JPEG 2000 compression, and, using “Mathematica” software, compared them with one another.
3. They created a computerized picture from a given set of data so as to give them the range of RGB (red, green and blue) values. They attended seminars and museums including the American Museum of Natural History.
4. They presented the end result of their projects at a research summit in NASA and also at a showcase presentation for the City College of New York.
5. All members of the team together wrote a research paper, some of which were submitted to various journals for possible publication.

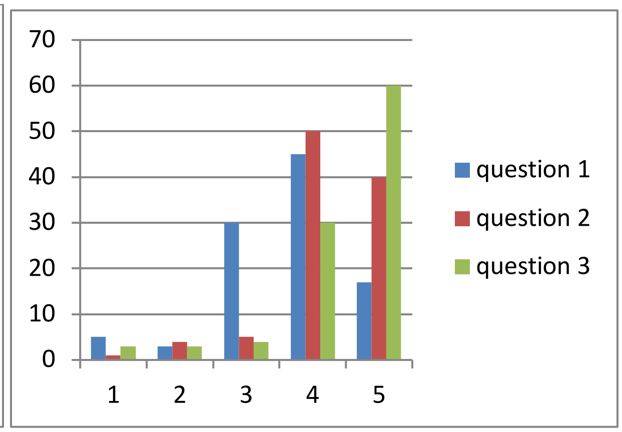
A Short Survey of our Summer Research:

Before and after each summer research, we conducted a brief survey to analyze how participants thought about the STEM program and how the summer research influenced their decisions. To make the survey simple, we asked participants to rank the following three statements measured on a scale of 1 to 5 (5=strongly agree, 4=agree, 3=neither agree nor disagree, 2=disagree, 1=strongly disagree):

1. I will do very well in my career in the STEM field.
2. I really like my subject and want to study further and get a graduate degree.
3. I will encourage my siblings to pursue a STEM career.

A bar graph of response before and after the summer research is given below, with data given in percentages:





Before Summer Research **After Summer Research**

Here, in the horizontal axis is given the scale of the response which is between 1 to 5, and in the vertical axis is given the percentage of the students who select the corresponding response. So, for example, before the summer research, only about 5% of the students agreed that they would pursue a graduate degree in the STEM field whereas after the summer research this number increased to 50%. This is a dramatic change. In general, we see from the bar graph above that the concentration of students before the summer research is between responses 1 to 3 whereas after the summer research there is an obvious shift toward the responses 4 to 5. Although the sample size (which is approximately fourteen times four or fifty six participants) is not large enough to draw general conclusions, we see the effect of summer research on participating STEM minority students.

Conclusion

This research initiative not only motivated undergraduate students but also encouraged high school students to choose engineering as their future major. At the same time, the knowledge and experience of the team effort can be carried to a classroom by high school teachers. This is a win-win situation for all the members of the team.

Bibliography

wikipedia. (2010). Retrieved from wikipedia.org: http://en.wikipedia.org/wiki/Motivation

Assessment, C. O. (Fall 2012). *Total Enrollment by Race/Ethnicity, Gender and College: Percentages*. Retrieved from http://www.cuny.edu/irdatabook/rpts2_AY_current/ENRL_0031_RACE_GEN_TOT_PCT.rpt.pdf

Bailey, T., & Alfonso, M. (2005). Path to persistence: Analysis of research on programs effectiveness at community college. (L. F. education, Ed.) *New agenda series, 6*(1). Retrieved from http://www.eric.ed.gov/PDFS/ED484239.pdf

Banks, J. (1988). Ethnicity, class, cognitive, and motivational styles in the college classroom. (N. Heights, Ed.) *ASHE Reader Series*.

Engle, J., & Tinto, V. (2008). Moving beyond access: College success for low-income, first generation students. *Pell Instiitue for the Study of Opportunity in Higher Education*. Retrieved from http://www.eric.ed.gov/PDFS/ED504448.pdf

McKeachie, W. (1994). *Teaching tips: A guidebook for the beginning college teacher* (9th ed.). Lexington, MA: Heath.

Ormrod, J. E. (2003). Educational Psychology: Developing Learners. Merrill Prentice Hall.

Susan, M., & Linda, N. (1998). Student learning styles and their implications for teaching. *Center for research on Learning and Teaching (Occasional Papers)*(10).

Tiberius, R. (1986). Metaphors underlying the improvement of teaching and learning. *British Journal of Educational Technology, 17*(2), pp. 144-156.