

# Work in Progress: Introducing Electrical and Computer Engineering to High School Math and Science Students

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**Abstract** – This paper describes the recent activities of Electrical and Computer Engineering doctoral students in the design, development, and implementation of lessons for high school mathematics and science classes. The graduate students, called Fellows, worked in secondary classrooms in the Cincinnati Public Schools District as a part of Project STEP at the University of Cincinnati, which is funded by the National Science Foundation GK-12 Program. The Fellows formed partnerships with secondary math and science teachers to generate new lessons, activities, and resources to enhance the STEM skills of high school students. Additionally, the Fellows used their engineering expertise to bring authentic learning experiences into the classroom and introduced concepts in their field of engineering to underserved student populations. This paper discusses observations and reflections by the Fellows regarding aspects of the activities that had the most impact on student learning and interest in engineering, which was measured by self-reported student surveys.

*Index Terms* – STEM education, secondary mathematics, secondary science, NSF GK-12

## INTRODUCTION

With the steady rise of well-trained engineers around the world, the United States faces increasing challenges to stay at the forefront of the global technology race. An important determinant of success will be the number and quality of engineers we produce from our colleges and universities, therefore recruitment of talented high school students to technical fields is a high priority. Unfortunately, the individuals with the most interaction with students, secondary mathematics and science teachers, often are unable to provide the necessary information to interested students because they lack the background, time, and resources to effectively introduce engineering concepts and careers.

To address these problems, Project STEP (Science and Technology Enhancement Program) was developed at the

University of Cincinnati with funding from the National Science Foundation. There are three primary goals of Project STEP: (1) to produce scientists and engineers who are experienced in bringing their technical expertise into the classroom, (2) to design, develop, and implement hands-on activities and inquiry-based projects relevant to everyday life, and (3) to encourage secondary students to consider engineering as a field of study in college and as a profession [1].

The key component to Project STEP is the Fellows, engineering graduate students who bring their research expertise into the secondary classrooms through lessons and activities. Through these lessons, high school students are exposed to engineering concepts and careers while they learn in an authentic, hands-on environment. Additionally, the lessons are aligned with state and national standards, thus the students are learning standard material in a new and exciting way.

This paper provides details about recent instructional activities developed by Fellows with Electrical and Computer Engineering backgrounds for secondary students. Two lessons are highlighted in which specific engineering concepts were integrated with subject area content in the form of hands-on activities. The lessons include teaching linear programming (algorithms) to Algebra II students and teaching data mining (database systems) to Physical Science students. By designing the activities around examples that were relevant to students, these lessons helped engage students and prompted positive feedback. This paper also discusses observations and reflections by the Fellows about the aspects of the activities that had the most impact on student learning and interest in engineering.

## ALGORITHMS

### A. Background

“Algorithms” took place in three (3) 50-minute periods, implemented in three 11<sup>th</sup> grade Integrated Mathematics classes at Shroder Paideia Academy. The focus of the lesson

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was to introduce the concepts of linear programming and algorithms to students who had little knowledge of computer programming. After an introductory multimedia presentation, the students were given manipulatives such as Lincoln Logs and K'nex and asked to construct an object of their choosing. While they were building their design, the students wrote detailed instructions for the placement of each piece, including x,y,z coordinate location on a sheet of graph paper located beneath their object. Then students swapped designs and tried to build the other student's object using only written instructions given to them.

### *B. Engineering Concepts*

Linear programming requires a set of instructions that is executed in a pre-determined order to accomplish a particular task. This activity shows students the importance of a correctly ordered and sufficiently detailed algorithm when trying to replicate a set of instructions. Additionally, students learn that unless specific terms are used to create a 'language' communicating a set of instructions can be quite challenging to write and still be efficient.

### *C. Results and Reflections*

The students were very interactive during this lesson due to its structure and the nature of working hands-on with manipulatives. Several students commented at the beginning of the lesson how the task would be really easy, but these same students later rescinded when they found out how hard it was to follow someone else's instructions. Feedback surveys showed 54% of students reporting an increase interest in engineering and 75% reporting more confidence in their ability to learn math and science.

## DATA MINING

### *A. Background*

"Mega Mining Mart" is a one (1) day activity (50 minutes) that was implemented in four 9<sup>th</sup> grade physical science classes at the Hughes Center School for Teaching and Technology. The focus of this lesson was to introduce students to the concept of data mining while remaining aligned to the Ohio state standards necessary for the chemistry portion of physical science. After a short introduction to the lesson and data mining, students were given a blank store layout and various items that can be found in any grocery store. They were asked to arrange the items in the store based on some known associations (such as people that buy peanut butter often buy jelly) that had been found via data mining. This store layout was related back to the arrangement of elements in the periodic table. In the periodic table, elements with some commonality are grouped into rows and columns. For example, the noble gases are all in the far right column. The majority of items in a grocery store are also arranged with at least some thought given to similar items. For example, all

bread (white, whole wheat, multi-grain, etc.) is usually found in the same aisle. While each type has differences, they are all linked together by their common features such as use and general shape and size. This connection allows students to visually connect the reasoning of the periodic table with something they are already familiar with.

### *B. Engineering Concepts*

Data mining is used by software engineers to find unique and previously unknown associations within a set of collected data. This data is typically transaction-based (such as that from a grocery store) and is stable (does not change once it is collected). Students see through the activity that software engineering concepts are used in everyday life and these same concepts can be applied to a wide range of problems that they are already familiar with.

### *C. Results and Reflections*

The students were very engaged in the activity and took it seriously. They enjoyed using manipulatives to arrange their store, and they also appreciated the creative aspect of the lesson. Several students commented that they were not aware of engineering being used so much in things they see and use everyday and how this was "cool." Self-reported surveys found that 50% of students reported an increased interest in engineering and 83% reported more confidence in their ability to learn math and science.

## CONCLUSIONS

This paper illustrates how advanced computing topics can be successfully integrated into high school math and science courses. Through these activities and many others, Project STEP is making inroads into secondary education by providing hands-on, engineering-based applications relevant to students' lives. The implementation of activities and presence of the Fellows in the classroom have resulted in increased engagement of high school students with STEM subjects and increased confidence in their abilities to learn these subjects. Teachers have benefited from exposure to engineering topics that broaden the applications of their disciplines. Details about lessons and achievements can be found at the Project STEP website [1].

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## REFERENCES

- [1] Project STEP website, [www.eng.uc.edu/STEP](http://www.eng.uc.edu/STEP), 2006.