Development and Implementation of a Structured Outreach Program in IT for Middle and High School Students

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Abstract

There is a growing concern in the U. S. over low enrollment of domestic students in the sciences, engineering and mathematic which may limit technical innovations in the country. This is further compounded by the expectation that future migration of technical workforce from developing countries would be limited. Consequently, there is a strong push to increase graduation of domestic students in the STEM disciplines. To address the problem the Detroit Area Pre-College Engineering Program, Inc., with active participation of six universities and corporations, designed and implemented a coherent program in information technology and related disciplines targeted at underrepresented minority students from the Detroit area. The project focuses on exposing students to science, engineering and technology disciplines with a goal of motivating them to pursue STEM based program after their graduation from high school. This paper describes the components of the overall project conducted at the University of Michigan-Dearborn and learning objectives and student outcomes in each of the classes offered at the institution during the first year of the project. A significant portion of the students participating in the program I year 1 achieved the outcomes and, in some cases, exceeded the expectations.

Background and Rationale

There has been a continued concern in the U. S. over the low enrollment of domestic students in the sciences, technology, engineering and mathematics (STEM) disciplines. On the overall, the enrollment of undergraduate students in engineering has steadily decreased from about 441,000 in mid-80's to about 404,000 in 2003, an almost 10% drop[1]. In fact, the number of students pursuing technical degrees in the U.S. would have been even lower had it not been for the recent interest in computer and IT related disciplines. There are strong indications that the number of domestic students enrolled in engineering and technology will continue to decline. The evidence so far supports the trend. This, combined with the expectation that future migration of technical workforce from developing countries would be limited, has provided further impetus to attract more domestic students into engineering and the sciences.

Inferences have been made that the steady decline of students in the STEM disciplines has more to do with the lack of interest on the part of students in the field and even more so in engineering

and technology areas. There have been unending debates at the state and federal levels on the lack of preparation of middle and high school students to tackle STEM areas. These concerns have resonated loudly in private and public sectors because of the global competition in manufacturing and technology areas. Several programs have been designed to address these issues and, at the same time, improve students' competencies in key subject areas involving mathematics and science. Due to federal mandate in the U.S. concentrated efforts continue to be expended to improve science and math competencies of students at all levels. While the students' scores in the subject areas have improved, critics claim that a great portion of the effort is directed at meeting test score requirements rather than improving students' fundamental understanding of the subject matter. It has been said again and again that strengthening students' fundamentals in math and science in schools would lead to their improved academic performance in colleges and universities.

The outsourcing of engineering and IT related services has created significant opportunities for engineers and computer scientists abroad to the extent that immigration of these technical personnel to the U.S. has decreased. Consequently, there are concerns that engineering and IT personnel in the U.S. will be in short supply in the years ahead[2].

As part of an overall effort to motivate students and create interest in science and technology a program was developed and implemented for middle and high school students in the Detroit metropolitan area. The program is administered by the Detroit Area Pre-College Engineering Program Inc. (DAPCEP), a non-profit organization, in partnership with several local universities and corporations. While DAPCEP has focused its activities in providing academic programs to Detroit area students for over 25 years the current DAPCEP-ITEST project is targeted at students' competencies in IT and related disciplines. The objective of the 4-year, 2-cycle project is to provide hands-on education and skills opportunities to underrepresented minority students from schools in the Detroit area. The major funding for the project is provided by the National Science Foundation (NSF) under the Information Technology Experience for Students and Teachers (ITEST) program. The University of Michigan-Dearborn, along with the University of Michigan-Ann Arbor, Michigan Technological University, University of Detroit-Mercy, Lawrence Technological University, and Ford Motor Company are providing the majority of instructional and laboratory activities to student participants.

Year-1 Program at UM-D

The University of Michigan-Dearborn (UM-D) is involved in the first year of each of the 2-year cycle of the project. It has offered instructional and hands-on activities to the 7th and 9th grade students during the first year of the first cycle of the project. This paper discusses outcome and assessment of the project based on the activities in the first year of the project. Sixty students in each grade level were admitted in the ITEST program. To facilitate management of Saturday classes, the 7th and 9th grade students were divided into two subgroups of 30 students each. The program was offered on six Saturdays of each semester, spanning a total of 18 contact hours of instructional activities per semester.

Table 1

Class Title	Target Group	When Offered	Duration and Contact Hours	Modes of Learning and Activity
Computer Programming and Algorithms	7th Grade	Fall Spring	6 Saturdays, 18 contact hrs.	Hands-on computer laboratory instruction
Web Page Design/Development	9th Grade	Fall Spring	6 Saturdays, 18 contact hrs.	Hands-on computer laboratory instruction
Laboratory Science and Computer Integration	9th Grade	Summer	4-week daily summer classes, 120 contact hrs.	Science experiments, data acquisition, data analysis w/software

The summer program was more intensive in nature and spanned over a period of 4 weeks of classes totaling about 120 contact hours. In addition to classroom and laboratory experience the students participated in field trips to science centers for a learning experience in a different environmental setting. The details of admission and enrollment process, including the rotational mode of students' participation at different campuses, have been reported in an earlier paper [3].

The major thrust of the UM-D project was to provide educational activities, combined with hands-on laboratory experience, in IT and related disciplines that use IT or rely on it in one form or another. Research has shown that students' learning is more effective if it is accompanied by hands-on activities. The UM-D committee overseeing the project felt that the planned educational approach was sound and would be effective in motivating the target students toward career opportunities in IT and STEM disciplines. The project also included evaluation of effective modes of learning IT and related skills in a classroom and laboratory environment.

Table 1 shows the schedule of Saturday and summer classes offered at UM-D during the first year of the program. The program committee developed educational objectives and outcome expectations for each of the classes offered at UM-D. These are described below:

A. Computer Programming and Algorithms

Objectives: To develop logical thinking processes that would help students to understand computer programming and help them develop elementary computer programs using a simple computer language such as QBASIC.

Outcome/Expectation: The students should be able to construct simple algorithms and elementary programs to solve STEM related problems.

Assessment Tools: The outcomes were assessed based on the students' performance through quizzes, assignments, class participation and presentations.

B. Web Page Design/Development

Objectives: To understand principles of web page development, software applications in web page design, and use of software such as FrontPage in web page development

Outcome/Expectation: The students should be able to design and develop simple web pages using at least graphics, texts and color. Incorporation of additional components such as audio and animation will be considered at a plus.

Assessment Tools: All participants had to develop web pages using one of the software, such as the MS FrontPage. Assessment of outcomes was made by evaluating designs and contents of the student's web pages, features in the designs and presentation of the web pages.

C. Laboratory Science with Computer Integration

Objectives: To learn and promote learning of science through activities and experiments and the use of database to collect and analyze data including presentation of results in simple graphical formats.

Outcome/Expectation: The students should be able to conduct science experiments in teams, have elementary knowledge of database to analyze data and produce results from experimental work. The students were expected to communicate their findings through written and oral presentations.

Assessment Tools: The outcome assessment was based on the students' laboratory work, integration of experimentally measured parameters into Excel database, use of Excel in analyzing data and representing results graphically, and interpretation of results. The assessment also included students' competence in oral and written communications at that grade level.

Program Details

The program committee, along with the instructors, identified several topics to be covered in each of the three courses during year 1 of the project. The topics were selected to meet the expected background of students, their initial competence level, and the objectives of the course and the project.

Computer Programming: A simple programming language, QBASIC, was used to teach concepts of computer programming and allow them to develop simple computer programs and elementary algorithms.

This decision was based on the students' level of preparation and their prior exposure to computer and information technology. The following is a partial list of the topics covered and practiced in the computer laboratory.

- Introduction to computer languages and to QBASIC
- Commands and statements in QBASIC with examples
- Input/Output Statements and their use
- Logical statements such as IF, THEN, GOTO, etc.
- Loops and statements for loops, issues with loops in a computer program
- Development of computer program, storage and retrieval to/from server
- Introduction to simple graphics in QBASIC

The students were required to practice each of the topics and work out problems and quizzes related to program development. At the end of the class the students were required to develop simple computer programs involving some of the tasks learned in the course. Examples of the students' work are shown in Appendix A.

Web Page Design and Development: The students' learning was focused on understanding and using Microsoft FrontPage software to design and develop web pages. The decision was made because the software did not require prior knowledge or understanding of HTML. The students' background and standing was not suitable for them to learn the language. A course focused on:

- Introduction to internet and relationship between the internet and the web
- Introduction to Microsoft FrontPage and use of the software
- Text formatting and image inclusion
- Links through web page and different styles of linking
- Use of tables for organized presentation of information
- Creation of web pages with color and elementary animation and audio

Appendix A shows examples of graphics and images in one of the students' web pages.

Laboratory Science with Computer Integration: The overall focus of the courses to introduce students to selected topics of science through hands-on experiments and activities and how computer technology can be used to collect data, compute and analyze results and develop simple technical reports. The students conducted experiments in chemistry, biology and physical and environmental sciences. Some of the activities included:

- Measurement of density of solutions and liquids
- Introduction to ecosystems through experiments using aquatic ecosystems
- Cell observation and development of cell model
- Simple electrical circuits and analysis through voltage and current measurements
- Introduction to acids, bases and antacids
- Organic synthesis and analysis through soap making

In several of the experiments the students used excel database to store, retrieve and share data, conduct simple calculations, store and analyze their results through graphical plots and created reports with graphical illustrations.

Evaluation and Performance

While it is too early to evaluate the impact of the program on students' interests in pursuing SEMT disciplines when they graduate from high schools the initial assessment indicates that the UM-D program developed a great deal of students' interest in IT and related disciplines. It is clear that the program improved students' understanding of IT topics including how computer technology can be utilized in scientific experiments.

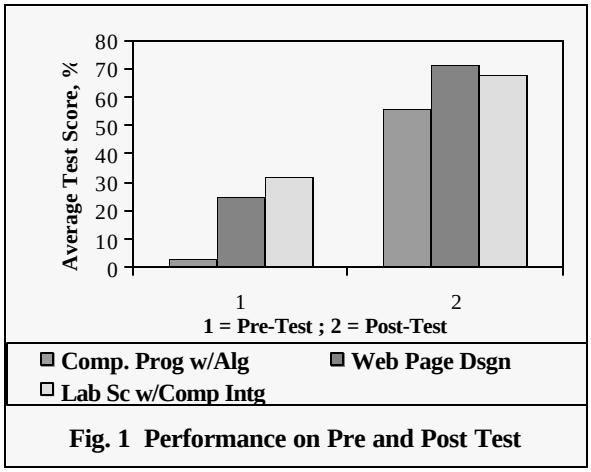

Fig. 1 Performance on Pre and Post Test

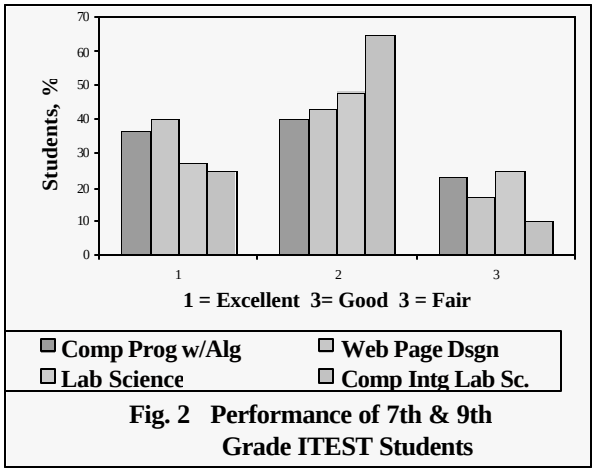

Fig. 2 Performance of 7th & 9th Grade ITEST Students

This was measured through pre and post-tests in each of the courses. Its was carried out in two ways: (a) the course instructors designed pre-tests and post-tests based on the course contents in the IT area, and (b) an external evaluator used standardized tests to evaluate students' knowledge before and after the course. Figures 1 and 2 show students' performance in the courses offered at UM-D during the first year of the program [3].

The assessment of all the 7th and 9th grade student participants was conducted by the course instructors using the instruments described earlier. It shows that most of the participants met or exceeded the outcomes and expectations, as shown in Table 2. Some of the 9th grade students' math preparation was less than adequate for their grade level. This was reflected in their performance in the laboratory science course, as shown in the table. This will be addressed in the next session of the program.

The National ITEST Learning Resource Center funded up by NSF at the Education Development Center (EDC) has recently highlighted the DAPCEP-ITEST program on its website. It includes comments made by students and their parents on UM-D program and on programs offered by DAPCEP partners. The students were very satisfied with the learning experience they had at

UM-D and stated that it has helped them in their academic work. These comments can be found at http://www2.edc.org/itestlrc/itestprojects/dapcep_mi.htm

Table 2
Percent of Student Participants Meeting Course Outcomes

Course Name	Exceeded	Met	Didn't Meet
Computer Programming w/Algorithm	30%	60%	10%
Web Page Design	35%	58%	7%
Lab Science w/Computer Integration	23%	57%	20%

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References

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Appendix A

Samples of simple computer programs:

Program to calculate average of a series of numbers

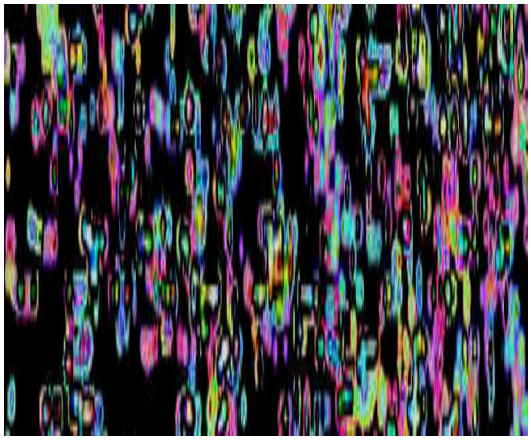
```
10 Screen 9
30 Rem
35 Let t=0
40 For X =1 to 7
45 Color 4,x
50 Input “Please enter a number”;i
60 Let t=i+t
70 Next x
80 Print “The average of 7 number”
90 Print t/7
100 End
```

Program to develop a graphic picture

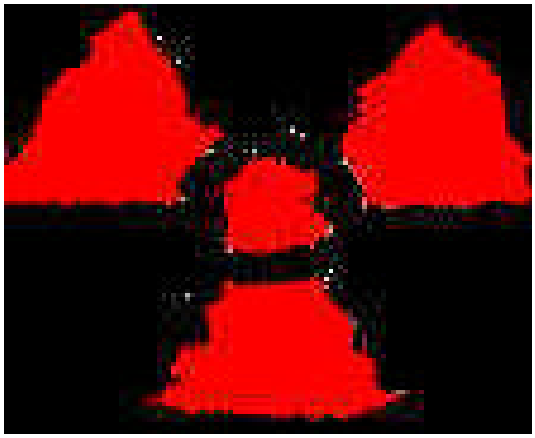
```
10 Screen 9
15 Circle (168, 45), 10
16 Circle (230, 45), 10
20 Circle (200, 45), 50
22 Line (0, 100)-(149, 100)
23 line (0, 100)-(59, 100)
24 Line (250, 100) -(400, 100)
30 Circle (200, 130), 65
40 Circle (200, 245), 90
45 Pset (200, 145)
46 Pset (200, 134)
47 Pset (200, 125)
48 Print “Happy Holidays”
49 Circle (200, 62), 5
50 Print “Happy Holidays”
51 Print “Happy Holidays”
52 CLS
54 Goto 15
55 End
```

Samples of graphical images created by students in their web page design course:

1. Color Graphics



2. Radiation Fallout



3. Creating Text and Graphics