Pre-College Program Designed to Benefit Graduate Students

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Abstract

The Wireless Integrated MicroSystems (WIMS) Engineering Research Center (ERC) has hosted about 20 to 30 Detroit Area Pre-College Engineering Program (DAPCEP) seventh and eighth grade students in each WIMS SuperStar Challenge pre-college Saturday program session starting in Spring 2002 through 2009, at The University of Michigan – Ann Arbor (UM), plus an extra session in Fall 2008 for the DAPCEP National Science Foundation (NSF) funded Innovative Technology Experiences for Students and Teachers (ITEST) program. Often these type programs are crafted as outreach to benefit K-12 students. Additionally, this K-12 program was designed to also benefit graduate and undergraduate students who serve as mentors (instructional program assistants).

During each of five Saturday sessions totaling approximately 20 instructional hours overall, the WIMS SuperStar Challenge program curriculum contained (1) instruction for science, mathematics, and engineering motivated with (2) hands-on experiments that incorporated concepts for construction, system operation, programming, physical science, microfabrication, wireless communication, sensing, actuation, control, and microsystems. Typically, each group of two DAPCEP students is mentored by a University graduate student in engineering, leading to a low student/mentor ratio. Each DAPCEP student receives personally focused instruction exercises and experiments, with emphasis to build upon each student's background knowledge and questions. Each mentor has responsibility to advance motivation and inquisitive attitudes in the DAPCEP student.

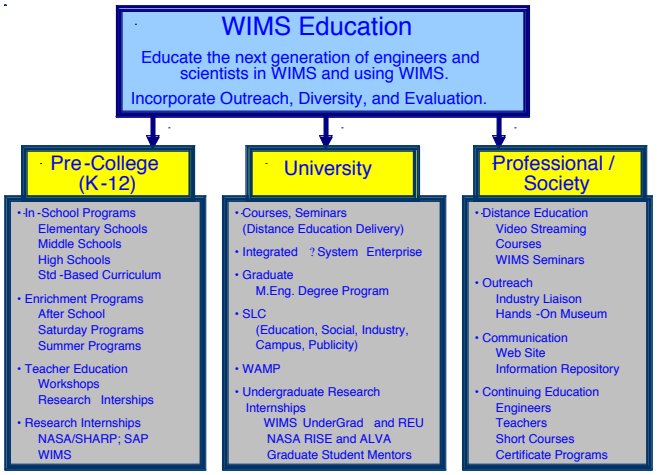
The paper describes the designed and derived benefits for mentors in this pre-college program, including training sessions for mentors to learn to: mentor, sense and interpret statements by students with emerging knowledge and understanding of the topic, motivate students for enjoyment and enthusiasm to acquire technical knowledge and develop academic growth.

WIMS – The Organization and Pre-College Education Programs

WIMS is a National Science Foundation Engineering Research Center, with detailed description at web-site [8]. WIMS is structured with nine thrust areas, one area being Education Programs.

Education Programs Thrust Structure: The goals of the WIMS Education Programs Thrust are to educate the next generations of engineers and scientists about WIMS and with WIMS, and to rapidly transfer results from the research domain to the classroom domain. Proactive diversity and outreach initiatives, as well as evaluation, are to be integrated within each program. As depicted in Figure 1, the Education Programs Thrust provides comprehensive opportunities with three sub-components: pre-college programs for K-12 students, university programs for undergraduate and graduate students, and professionals/society programs for practicing professionals and society.

Figure 1 – Comprehensive Scope for WIMS Education Programs.



Pre-College Education Structure and Programs: The goal of the WIMS pre-college effort is to increase the number of students that select science, engineering, and math as their major in college, as well as to improve their academic ability and preparation to enter those majors [6][8]. The strategy is to provide programs for in-school, teacher education, and enrichment (after-school, weekend/Saturday, and the summer). WIMS pre-college education programs are characterized by two key factors:

1. Emphasis is on WIMS core concepts (microsystems, microfabrication, wireless communication, sensors/actuators, microcontrollers), along with societal impacts.
2. Educational programs have academic content that is a subset of core concepts.

The specific topic of this paper is the design of a pre-college Saturday program to benefit graduate and undergraduate students, though the explicit overt focus is the education and motivation of middle-school seventh and eighth grade DAPCEP students.

DAPCEP – The Organization

Students in the Saturday program are participants in the Detroit Area Pre-College Engineering Program (DAPCEP). To better understand the program, the DAPCEP mission, goals and objectives as found at the DAPCEP web-site [3] are repeated here:

Mission: DAPCEP's mission is to increase the number of historically under-represented minorities (African-American, Hispanic-American, and Native-American) who are motivated and prepared academically to pursue careers in science, mathematics, engineering, and technology-related fields.

Goals and Objectives: DAPCEP's ultimate goal is to give underrepresented students the interest and preparation needed to succeed in a University-level science or engineering curriculum.

DAPCEP achieves results by offering intensive computer, technology, science, math, and engineering training from experienced professionals and instructors in their respective fields. Students receive hands-on opportunities in work environments in addition to classroom-based curriculum activities.

Saturday Programs: DAPCEP collaborates with colleges, universities, and corporations to provide innovative and interactive classes to children in grades K-12. Classes focus on quantitative subjects such as mathematics, computer science, engineering, physics, and chemistry. Equally important qualitative skills are taught including communication skills, networking, teamwork, resume writing, professional etiquette, and time and resource management.

In addition to DAPCEP's mission, goals, objectives, programs, and organizational structure, a very important feature

that attracted WIMS to work with DAPCEP is its very strong parent organization, with highly committed and active parents. The strong DAPCEP parent organization was a great influence on the design, recognizing that the family would motivate the students to work, learn, and achieve.

WIMS SuperStar Challenge Saturday Program

The WIMS SuperStar Challenge program is the topic of another paper [6]. The program is briefly overviewed here to provide a basis for the Mentor tasks, the topic of this paper. For academic content, DAPCEP students are introduced to WIMS technical topics of engineering, science (physics, chemistry, biology), mathematics, transducers (sensors, actuators), microfabrication, wireless communication, microsystems, and society beneficial applications.

During each of five Saturday sessions totaling approximately 20 instructional hours overall, the WIMS SuperStar Challenge program curriculum contained (1) instruction for science, mathematics, and engineering motivated with (2) hands-on experiments that incorporated concepts for construction, system operation, programming, physical science, microfabrication, wireless communication, sensing, actuation, control, and microsystems. The first two Saturday sessions were devoted to flexible adaptable construction of electrically-powered LEGO robots to introduce microsystems, wireless communication, sensors, programming, and control algorithms. The third session was devoted to biomedical micro-probes electrode arrays with dual application as sensors for health-care monitoring and as actuators for delivering health-care treatments. The fourth session was on computer concepts, starting with the binary number system and logic, leading to digital functions and electronic gates, and medium-scale functions such as half adder or decoder as a sub-component of a microprobe microsystem design. The fifth/last Saturday session includes a nanocamp that provides an opportunity for each student to do a fabrication process to write a pattern on a wafer that he/she takes home as a memento. The curriculum topics are coordinated because each week a student group designs [5], constructs, and tests a portion of the ultimate goal (a microsystem with microprobe simulated by varying color LEDs, electronic digital small-functional system, and programmed LEGO robot. At the end of each five Saturday sessions program, students get items to take home to show parents, family, and friends. One take-home item is the wafer that each student wrote a pattern. Second/third take-home items are both WIMS SuperStar Challenge and DAPCEP certificates.

Consistent with DAPCEP mission and goals, the WIMS SuperStar Challenge program was designed to:

- provide weekly learning experiences in engineering, with special focus on WIMS technical educational content and applications;
- prepare and improve participants technical, analytical, and problem-solving skills;
- enhance student personal growth;
- present University of Michigan students as successful role models;
- provide information on career opportunities in engineering, and
- arrange presentations by internationally renowned faculty and leading researchers

Over the long term of many years of such pre-college programs, another goal is to

- increase the number of well prepared students that select engineering, science, and math as their future university major leading to professional careers in those disciplines.

Students are selected either by DAPCEP or by WIMS review of applications. Round-trip transportation is arranged between Detroit and Ann Arbor (a distance of about 45 miles). Funds to pay program expenses (now about $5,000 per 5 Saturdays) are contributed by the Electrical Engineering and Computer Science (EECS) Department at The University of Michigan, WIMS, and DAPCEP. A portion of the program expenses is payment of a small token stipend to the WIMS Program Coordinator and Program Assistants (Mentors). The author had been faculty advisor for the EECS DAPCEP program for 12 years of a 15 years relationship. The WIMS structure with mentors program design has existed for 8 of the 15 years.

Mentors as Program Assistants – Graduate and Undergraduate Students

The WIMS Center has internationally renowned faculty, post-doctoral fellows, outstanding graduate students, and technical staff members to make technical content presentations. Over the years, faculty members and advanced PhD students have made presentations on society beneficial application topics that include environmental monitoring, microelectromechanical systems (MEMS), brain research, microprobes for sensing and stimulation treatments for ailments such as Parkinson's and epilepsy, infrared imaging, and microsystems.

Less advanced graduate students, along with undergraduate students, serve as program assistants, referred to as Mentors in the WIMS SuperStar Challenge program. Mentoring is one of the most important design features of WIMS pre-college programs and has immense benefits. Moreover, part of the designed intent of this program was to benefit the graduate and undergraduate student program assistants – the Mentors.

Mentors serve a crucial role to achieve the WIMS and DAPCEP goals by providing personal attention to the DAPCEP students. Mentors are charged with the responsibility of supplementing the design goals in the bulleted list on the previous page, by ensuring that each student understands the instructional presentations and can do the hands-on exercises each Saturday. Typically, each group of two DAPCEP students is mentored by a Mentor engineering student; in practice, no more than two groups per Mentor; ensuring a low student/mentor ratio.

Mentors help the middle-school students enthusiastically learn technical knowledge and develop academic growth goals. Specifically, the WIMS mentors help the students understand the instructional presentations by the WIMS faculty. The Mentors help the middle-school students understand and carry-out the construction, fabrication, and testing processes for the specific hands-on experiments for the day. Thus, DAPCEP students receive personal attention to focus activities, learning, and progress for each individual, with special emphasis to build upon each student's background knowledge and questions. Each mentor has responsibility to advance motivation and inquisitive attitudes [7][5].

Many Mentors are volunteers of the WIMS Student Leadership Council (SLC), with specific leadership from the chairperson of the SLC Education Committee, and other members of the SLC. Getting SLC volunteers for the nanocamp session has been an easy request to fulfill, as SLC graduate students take pride to discuss their individual research with DAPCEP students. This aspect contributes to the program design goals of role models and career opportunities. Enthusiastic Mentors have volunteered from two other key local student organizations: the National Society of Black Engineers (NSBE), and the Society of Women Engineers (SWE). Several Mentors have refused to accept the small token stipend, insisting to be pure volunteers.

Mentor Training: To facilitate the crucial role of mentors, typically two mentor training sessions are held prior to the start of each program. The two sessions are scheduled trying to find a time to accommodate the schedule for each Mentor. The two sessions are repeat content. Also, to boost attendance, lunch or early evening dinner is provided.

During the Mentor training session, content topics address:

- WIMS and DAPCEP goals for the Saturday program
- Overview of the technical content for the Saturday program sessions: both overall program technical content and each Saturday content
- Schedule for a typical Saturday, with time out for lunch
- Goal of 1 Mentor per 2 DAPCEP students
- Building a personal relationship with the group to 2 DAPCEP students
- Importance of regular attendance to promote personal relationship and confidence
- Learning methods, using content from several reference sources [1][2][4][5][7]
- Methods to ascertain level of student existing knowledge
- Interpreting statements by students to ascertain knowledge and understanding of topic
- Teaching methods to help student learn new technical material [7]

- Motivating efforts to learn (with fun learning approaches)
- Developing confident and enjoyable learning
- Developing individual plan of study and learning for each K-12 student

Our assessment is that the mentor training sessions have had an important impact on Mentor capabilities to help DAPCEP learn WIMS technical content. Mentors are crucial, and make important contributions, to the WIMS K-12 pre-college programs.

In addition to the Mentor training sessions, before each Saturday session, Mentors are asked to arrive early so the schedule, technical content, instructional topics, and hands-on experiments for that day can be refreshed and reviewed with reminders, allowing time to answer questions from the Mentors. Also, Mentors help set-up the equipment for the day.

Benefits of Mentor Process for DAPCEP Students

Positive evaluations for the Mentor process and the low student/mentor ratio have been offered from several sources. A DAPCEP ITEST Program Coordinator visited and reviewed each program twice during each ITEST session in 2008. After her visit to WIMS, and during the next DAPCEP ITEST meeting with program faculty, the DAPCEP ITEST Program Coordinator praised and used the WIMS mentor structure as a suggested template to other DAPCEP ITEST university program providers. Several times, she stated that having one WIMS Mentor assigned to each group of two DAPCEP students provided the personal attention that facilitated student learning. Other DAPCEP administrators have made positive comments about the WIMS Mentor process. Also, the DAPCEP ITEST Program Coordinator reported that DAPCEP students made positive comments to her on the low ratio of 1 mentor to 2 DAPCEP students. Also, end of program surveys reveal DAPCEP students evaluating highly the personal mentors process.

Benefits to DAPCEP students:

- DAPCEP students see multiple viewpoints for technical content:
  Viewpoint of both faculty presenter and Mentor
- DAPCEP students have access to strengths of people and university facilities
- DAPCEP students learn to work with new and technically capable Mentors
- DAPCEP students learn to work with international students from countries such as (in alphabetical order) China, France, Ghana, Iran, Korea, Malaysia, Peru, Turkey, and others, in addition to United States students (See Figure 2 photo)

Figure 2. Some of the Mentors for Fall 2008 Session (and 2009 SLC Officers)

Benefits to Mentors
(Benefits to Program Assistants – Graduate and Undergraduate Students)

Though these type programs are often referred as outreach to benefit the K-12 students, part of the design and intent of this program was to benefit the graduate student, undergraduate student, and Post-docs being prepared to serve as program assistants, mentor, teacher, and role models, while working with others in their learning pursuits.

An aspect of the NSF ERC Programs is to have graduates that enter industry or university careers ready and prepared to make contributions. The WIMS ERC has goals to get graduate students involved in initiatives that gain them experience with working in teams, carrying-out interdisciplinary projects, planning project goals and tasks, with timelines included in plans. Thus, WIMS pre-college programs are intended to serve the graduate research student also, with benefits flowing to undergraduate students also. In addition, WIMS seeks to engender a community service volunteer spirit in the students.

Why is mentoring part of the WIMS ERC Education Programs goals? Industry wants graduates that are ready to work in teams, work with others, do interdisciplinary work, plan and conduct projects and research independently with self motivation. Industry is seeking professionals with demonstrated leadership, supervision, project planning and system/task integration. Industry wants better prepared leaders. Universities are seeking faculty better prepared as teachers with leadership skills, with the ability to teach and motivate graduate students to conduct research. A volunteer community service attitude is important for professionals to further professional society organizations that advance continuing education and lifetime learning for professionals.

Some Benefits for Mentors

- Graduate and undergraduate student Mentors gain experiences of planning, including timelines, management, supervision, leadership, and mentoring
- Mentors transfer technical knowledge and construction/fabrication processing capability to middle-school students
- Mentors contribute huge time and thought commitments to benefit pre-college students
- Mentors reinforce (and sometimes strengthen) their science and basic engineering knowledge. Over the years, some mentors have volunteered with a goal to refresh science and engineering concepts in a discipline different than his/her major in college
- Mentoring facilitates students to become familiar with (or refresh) MEMS, microsystems, and applications that are not part of their typical research or classes
- Mentors become familiar with "cutting-edge" applications of the WIMS Center research
- Mentors become familiar with learning styles and methods (via mentor training sessions); a personal benefit is familiarity with his/her own learning style and strengths
- Undergraduate students form networks with graduate students, creating new mentor relationship opportunities for graduate and undergraduate students
- Mentoring motivates students to pursue graduate degrees in science and engineering

Summary and Conclusions

The specific topic of this paper is the design of a pre-college Saturday program that benefits graduate and undergraduate students, though the explicit overt focus is the education and motivation of middle-school seventh and eighth grade DAPCEP students. WIMS SuperStar Challenge is a Saturday program designed to help middle-school students improve their technical knowledge of science, engineering, and mathematics, and to have enthusiasm for future careers in technical fields; while dually designed to benefit undergraduate students, graduate students, and Post-docs serving as program assistants Mentors improve their capability to plan with timelines, supervise, manage, provide leadership, and gain knowledge of learning styles. Mentors serve a crucial role by providing personal attention to the DAPCEP students, a feature that DAPCEP students and administrators have evaluated highly. The ultimate benefit to the Mentor is better preparation to enter industry or university careers.

Changes are happening in the technical capabilities, confidence, maturity, and broad experiences for graduate and undergraduate students in universities. Students are receiving recognition and awards for outreach and community service contributions. Iimportant benefits are happening for university students with regard to academic capabilities, maturity to plan and assess progress of projects, motivation and evaluation capabilities, management, personnel supervision, and mentoring experiences, etc. And, many faculty more readily approve their research graduate student

to join in outreach initiatives. Indeed, the culture of undergraduate and graduate engineering education is changing at our universities, and that culture is being disseminated to pre-college institutions and students via Saturday and Summer Programs.

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List of Acronyms

DAPCEP	Detroit Area Pre-College Engineering Programs
EECS	Electrical Engineering and Computer Science Department (at UM)
ERC	Engineering Research Center
MEMS	Microelectromechanical Systems
NSBE	National Society of Black Engineers
NSF	National Science Foundation
SLC	Student Leadership Council
SWE	Society of Women Engineers
UM	The University of Michigan – Ann Arbor, Michigan
WIMS	Wireless Integrated MicroSystems