

AC 2007-2757: TECHNOLOGY EDUCATION IN K-12: REVELATIONS FROM DESIGNING AND DELIVERING A ROBOTICS LESSON PLAN FOR PRE-SERVICE TEACHERS

Abhijit Nagchaudhuri, University of Maryland-Eastern Shore

Abhijit Nagchaudhuri is currently a Professor in the Department of Engineering and Aviation Sciences at University of Maryland Eastern Shore. Prior to joining UMES he worked in Turabo University in San Juan , PR as well as Duke University in Durham North Carolina as Assistant Professor and Research Assistant Professor, respectively. Dr. Nagchaudhuri is a member of ASME, SME and ASEE professional societies and is actively involved in teaching and research in the fields of engineering mechanics, remote sensing and precision agriculture, robotics, systems and control and design of mechanical and mechatronic systems. Dr. Nagchaudhuri received his bachelors degree from Jadavpur University in Calcutta, India with a honors in Mechanical Engineering in 1983, thereafter, he worked in a multinational industry for 4 years before joining Tulane University as a graduate student in the fall of 1987. He received his M.S. degree from Tulane University in 1989 and Ph.D. degree from Duke University in 1992.

Madhumi Mitra, University of Maryland-Eastern Shore

Madhumi Mitra is currently an Assistant Professor of Biology and Environmental Science at University of Maryland Eastern Shore. She is also the Coordinator of the Biology Education program at UMES. Dr. Mitra obtained her Ph.D. degree in 2002 from the Department of Botany at North Carolina State University. She is actively involved in research in the fields of marine biology, environmental science and paleopalynology.

Technology Education in K-12: Revelations from Designing and Delivering a Robotics Lesson Plan for Pre-Service Teachers

Abstract

In partnership with NASA, National Institute of Aerospace (NIA) and Bennett College for Women, University of Maryland Eastern Shore (UMES) hosted the 11th Pre-service Teacher Program. The program had two significant components: a) A national Pre-service Teacher Conference (PSTC) held at Alexandria, VA, during February 16-18, 2006, that drew participation from HBCUs (Historically Black Colleges and Universities), HSIs (Hispanic Serving Institutions), TCUs (Tribal Colleges and Universities) and majority universities with significant minority enrollment and b) An intensive two week Preservice Teacher Institute (PSTI) in the summer for a relatively small group of pre-service teachers held at NASA Langley for inspiring future K-12 teachers in the fields of mathematics, science, and technology education fields. This paper will focus on a robotics activity designed by the primary author for the PSTI. While designing the activity the technology education standards as proposed by ITEA (International Technology Education Association)/CTTE (Council on Technology Teacher Education) and ISTE (International Standard for Technology Education) were consulted and incorporated in the lesson. For the primary author, who is an engineering educator the experience revealed the confusion that prevails in the teacher education field with regard to “technology education” and its evolving standards. It is important for engineering educators to get involved and facilitate K-12 curricula development efforts based on these standards, and provide clarity to how “technology education” in the K-12 is related to vocational technology, instructional technology, mathematics, sciences, engineering and engineering technology.

1. Introduction and Overview of the PSTP 2006

The need for emphasis in (Science, Technology, Engineering, Mathematics) STEM education in K-12 and beyond is paramount to the development of the future workforce of the nation and its’ ability to compete successfully in the increasingly technology driven global market of the future. The future workforce in STEM areas will have to successfully attract individuals from the underrepresented minority population to meet the vast human resource needs ^[1, 2]. NASA along with NSF, Department of Education, and other federal agencies are playing an active role in these efforts. PSTP is one such project developed and implemented by NASA for pre-service STEM education majors in partnership with colleges and universities of higher learning. The PSTP project has been ongoing since 1995 with the overarching goal of providing enrichment activities to pre-

service STEM teachers, expose them to best practices in K-12 STEM education, and introduce them to advanced technologies utilized at NASA, government laboratories, and modern industries that have relevance to K-12 STEM education.

UMES partnered with NASA, National Institute of Aerospace, and Bennett College for Women to host the 11th Pre-service Teacher Program for the first time. As in the past the primary emphases were on (i) Pre-service Teacher Conference (PSTC) held in February 15-17, 2006 in Alexandria, VA, and (ii) Pre-service Teacher Institute (PSTI) an intensive two-week institute held at several NASA centers throughout United States in partnership with neighboring colleges/universities. UMES and Bennett College for Women coordinated the PSTI held at NASA Langley from July 16 through July 28, 2006.

2006 PSTC attracted more than 330 pre-service STEM teachers and faculty advisors from all across the nation representing Tribal Colleges and Universities (TCUs), Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), and majority universities with active minority programs (Figure 1a and Figure 1b below provide gender distribution and ethnicity of the participants.) Besides inspirational speakers who have made an impact on K-12 education representing ethnic and cultural diversity among the underrepresented minority population in the United States, more than 60 workshops relevant to STEM education including a few related to interview skills and class room management skills were held during the conference. Teams from almost all participating institutions took part in the “Poster Contest” and “Talent Show” held during the conference. 35 organizations all over the United States sent representatives for the “Career Fair” component of the conference. A significant number of the pre-service teachers found possible future employers/graduate school programs from among these recruiters and few were offered teaching positions subsequent to interviews held during the conference. 11th PSTC was rated to be the one of most well coordinated and successful efforts by the faculty advisors who participated in similar conferences in the past.

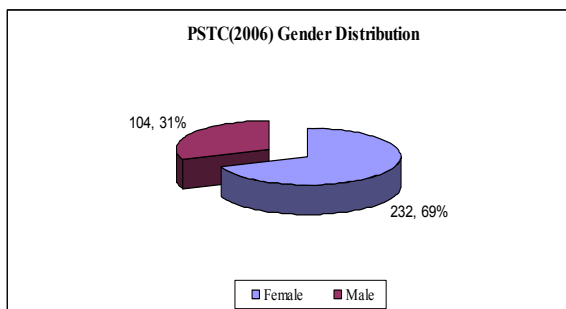


Figure 1a: Gender Distribution of PSTC 2006 Registrants

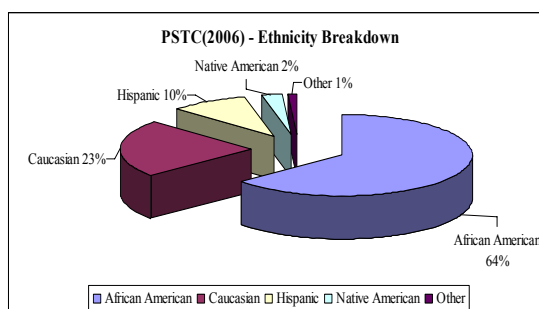


Figure 1b: Ethnicity Breakdown of PSTC 2006 Registrants

The 2006 Pre-service Teacher Institute (PSTI) held at NASA Langley was attended by 24 pre-service teachers who were selected from a nationwide pool (Figure 2a and Figure 2b provide the gender and ethnicity distribution of the participants). A significant component of the institute was a problem based learning (PBL) endeavor that integrated instructions on lesson planning, mathematics, science, and instructional technology around an aerospace related theme. The institute participants worked in teams to develop and

deliver a lesson to a group of elementary/middle school students based on the theme. Other activities included exposure to NASA Langley research projects, visit to Air and Space Museum and a science laboratory at Norfolk State University, a workshop on diversity issues relevant to K-12 education, a workshop on wireless technology and distance learning, and a “robotics workshop” designed and delivered by the principal author of this paper. All the activities were integrated into a 3 credit course offered through Department of Education at UMES, titled “EDCI 498 - NASA Internship Experience for Elementary/Middle Mathematics, Science and Technology Pre-Service Teachers”. Interested readers can visit the URL: <http://www.umes.edu/PSTP> to get more information on PSTP project and the PSTC and PSTI components integrated within it.

While developing the lesson plan for the “robotics workshop” the evolving standards for science, mathematics and technology education in K-12 for the new millennium were consulted to effectively address them. Technology standards for K-12 as developed by International Society for Technology Education (ISTE) [3] as well as International Technology Education Association (ITEA)[4] were reviewed by the authors for an insight into the trends in “Technology Education” in K-12. The exercise was an eye opener for the primary author and provides the motivation for the remaining sections of the paper that addresses (i) STEM education in K-12 and beyond in the United States with particular emphasis on “Technology Education”, (ii) the robotics workshop designed by the primary author for the 2006 PSTI and how it was utilized to clarify to the participants the broad meaning of the term “technology” and the common misperceptions that result from everyday associations of the term in rather narrow contexts, and (iii) possible future efforts integrated with the PSTP and other similar programs that can effectively champion STEM education and in particular “Technology Education” in K-12 settings.

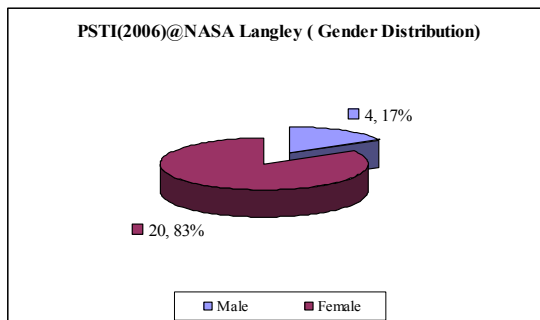


Figure 2a: Gender Distribution of PSTI 2006 Registrants

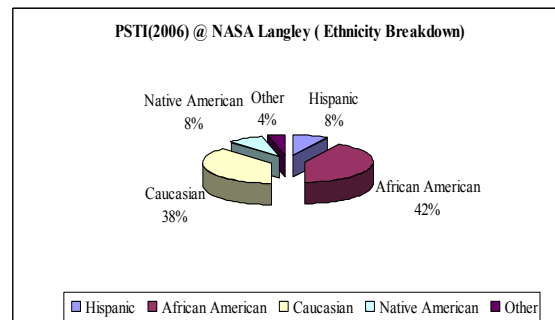


Figure 2b: Ethnicity Breakdown of PSTC 2001 Registrants

2. Technology Education and Standards for Technological Literacy in K-12

The everyday perception of the term “ technology” is often associated with “ information technology”, “electronics and computer technology”, “instructional technology”, “wireless and communications technology”, “medical technology” as well as, although, perhaps less frequently with “transportation technology”, “manufacturing technology”, “agricultural and biotechnology” , “energy and power technologies”, and “construction technology”. Although they all represent aspects of technology but society at large seems to lack a firm grip of the implications of this term and often misrepresent the term or more commonly define it in the narrow perspective of the context in which it is used [5]. This is the challenge that “Technology education” in the K-12 proposes to overcome with

the framework provided by the Standards for Technological Literacy (STL) ^[6] developed by ITEA/CTTE, and lay down the foundations for a broad based technologically literate citizenry. STL defines technology broadly as “how humans modify the world around them to meet their needs and wants, or to solve practical problems”.

STL addresses five subject matter standards which include; (i) Nature of technology, (ii) Technology and society, (iii) Design, (iv) Abilities for a technological world and (v) Designed world. These five subject matter categories have been expanded into 20 different STL standards. The STL standards 14 through 20 cover technologies that dominate the designed world in which we live today. It is not surprising that the STL standards parallel the program outcomes outlined for engineering programs by the Accreditation Board of Engineering and Technology (ABET) ^[7] and provides a continuum for engineering and technology education in the K-16 system. Development and effective implementation of “Technology Education” curricula based on these standards at the elementary, middle, and high school levels in concert with science and mathematics education and their respective standards ^[8-10] will complete the K-12 STEM education framework for the new millennium, with appropriate interfaces to higher education in engineering and technology fields in colleges and universities.

“Science Education” and “Mathematics Education” have been an integral part of a broad based school curriculum for all students. “Technology education”, however has been primarily associated with “vocational technology” and “industrial arts” in the past in K-12 settings, and have provided training of manual and psychomotor skills associated with the so-called “blue collar professions” to a clientele in the school system that did not represent the mainstream. There seems to be a growing realization that the need for such skills and professionals will diminish in the United States with the influx of automation technology and significant outsourcing of “blue collar jobs”. The goal of “technology literacy” for all Americans ^[11] as advocated by ITEA endeavors to bring “technology education” to the mainstream of K-12 clientele, in a similar footing with “science” and “mathematics” education, with a shift in focus consistent with what may be termed as “pre-engineering”. Emphasis will be on problem solving and design efforts in the “cognitive domain” often in an integrated framework with science and mathematics components in a similar vein as engineering education ^[12, 13]. The advocates of this new approach for “technology education” in K-12 settings feel that this is consistent with the goal of technological literacy for all Americans as well as advanced technology based predominantly “white collar” STEM related workforce requirements of the future. It is not surprising therefore that Massachusetts, which was the first State to adopt this trend advocated by ITEA at a comprehensive scale, and developed curricula at the elementary, middle, and high school levels consistent with the STL, have chosen to call it “Technology/Engineering” Curriculum Framework ^[14].

Present structure for “Technology Education” represents a paradigm shift which was initiated by renaming American Association of Industrial Arts (AAIA) to International Technology Education Association (ITEA) in 1985. While the framework has been laid out and the future has been clearly outlined, a significant number of K-12 school systems are struggling to transition from “industrial arts” to “technology education” ^[15-17].

Unique approaches are also evolving to develop school teachers who have formal training in the field of engineering [18, 19].

It may not be out of place here to mention college level “engineering education” has been separated into two major divisions in the United States, one is called “engineering technology” and the other simply “engineering”. Both offers ABET accreditable 4 year baccalaureate degrees. The primary difference being, one is more focused on providing proficiency in existing technologies of the designed world by “hands on” exposure (engineering technology), while the other dwells more in the abstract domain of pushing the envelope of technology by design innovations (engineering). “Engineering” students are required to take more higher level Calculus based mathematics courses to perform complex design analysis, whereas “Engineering technology” students tend to be more “hands on” and are not required to take some of the advanced mathematics classes. The division is somewhat artificial and has its’ roots in the so-called “blue collar” and “white collar” aspects of engineering profession. In recent years the line between these divisions has become blurred in response to new ABET and TAC-ABET accreditation criteria and their “outcome” based approach. As K-12 “technology education” efforts evolve more towards a “pre-engineering” framework, representatives of higher education who interface with the school system should be prepared to represent the “engineering” and “engineering technology” components of college education with clarity.

Given the shifting trends in the job market and the projections for the future workforce requirements in the United States, the economic justification for “vocational technology” and “industrial arts” programs in K-12 education may have become irrelevant, but careful attention should be paid to how some of its’ content can be integrated within the new “technology education” framework, in a fashion that is consistent with it’s “pre-engineering” inclination. The “engineering” and “engineering technology” professionals and educators can play a significant role in helping with this transition in the K-12 system.

3. Robotics Workshop in the PSTI 2006

The “Robotics Workshop” that was conducted during PSTI 2006 at NASA Langley provided an opportunity to introduce the participants to “technology education” standards. The activity was designed to show how the integrative nature of technology lesson plans can not only address the *Standards for Technological Literacy* but also reinforce mathematics and science concepts.

The workshop was designed as a team activity. The 24 participants were divided into 6 teams and each team was provided with a worktable and essential components of a “Lego Mindstorm – Robotic Invention System” kit that could be assembled together to build a robotic tank-like device. Figure 3 is a photograph of a complete Lego-based robotic tank (tankbot) [18]. Each team was also provided with a laptop computer loaded with Robotics Invention System (RIS) 2.0 software for program development, and an infrared tower that could be connected via an USB port to the laptop computer to download programs using wireless technology (infrared beam) to the RCX-brick (the big yellow piece in Fig 3) that formed an integral part of the tankbot.

The principal author developed a Power Point presentation for the workshop. The presentation was projected using a digital projector to a big screen for all teams to view. The presentation was initiated with a discussion of the social implication of robotic technology under the framework of three laws of robotics by Asimov^[19], followed by discussions on fundamentals of mechanics, sensing, and control of robotic and mechatronic devices^[22]. An overview of the RCX brick was also provided and it was pointed out that the brick has interfaces for three sensors and three motors and an embedded computer chip that can execute programs developed using RCX code in a laptop or a desktop computer and downloaded to it using a wireless infrared signal. The Power Point presentation also included an animation of the assembly sequence of Lego pieces developed in 3-D Computer Aided Design (CAD) environment as they come together to form the complete tankbot, and, fundamentals of programming using RIS 2.0 RCX Code. The movie of the animated assembly sequence for the tankbot facilitated the building of the device without too much loss of time, so that more time could be spent programming the devices to perform tasks such as (i) react to its' environment using sensor feedback, (ii) follow appropriate trajectories such as straight-lines, circles, squares/rectangles etc. of specified length and dimensions, and (iii) execute motion with spatial and temporal constraints. Student teams were encouraged to apply basic mathematical skills and device specific knowledge as they explored the solutions. Whenever the opportunity arose, related concepts in physical sciences were also discussed, for instance, basic ideas of electromagnetic waves, visible spectrum, infrared, and ultraviolet frequencies were discussed to explain the use of wireless infrared communication technology for program downloading. Students were also quick to understand the concept of friction by noticing how the device slowed down while running on carpet as opposed to the table top. The workshop concluded with an assignment for each student to develop a lesson plan based on the activity they participated in, for elementary/middle school "technology education" class. Each student was provided with a Lego Mindstorm guidebook^[18] and hyperlinks to various internet sites that provided

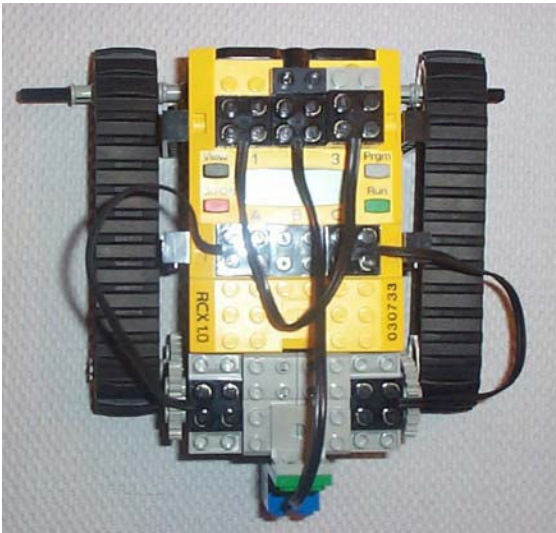


Figure 3: FullyAssembled Robotic Tank (Tankbot)



Figure 4: Robotic Workshop Session at 2006 PSTI

information on the new paradigm of “technology education” for K-12. The evaluation of the lesson plans developed by the students formed an integral part of the EDCI 498 course assessment. Figure 4 is a photograph taken during the robotic workshop session at the 2006 PSTI in the Office of Education facilities at NASA Langley.

All the pre-service teachers enthusiastically participated in the workshop and were excited about introducing lessons based on the workshop in their future teaching careers in the K-12 system. This excitement was clearly evidenced in the creative lesson plans developed and the feedback they provided. While most of the students developed lesson plans that integrated mathematics and technology standards with Lego Mindstorm based activities one of the institute participants ventured to develop sensor based robotics activity that integrated concepts from biology/biological sensor systems. Leaving aside the “lesson plan development” assignment, the entire workshop was completed in one afternoon (July 18), so there was little time left to reflect on the ramifications of the workshop with regard to the new paradigm of “technology education” in K-12 setting. However, the participants readily realized how “instructional technology”, “computers”, “computer graphics”, “information technology”, “science” and “mathematics” content, can be integrated within a “technology education” lesson over and above providing a platform for discussion on social and ethical implications of advanced technologies, and the engineering design process. It is this integrative holistic nature of “technology education” that the new standards aspire to promote which has the potential to significantly transform and improve K-12 STEM education and unleash the creativity of young minds throughout the nation. In the recent past, the primary author has explored this approach in developing a mathematics course for in-service high school teachers ^[23]. All teachers who registered for the course for professional development credits, overwhelmingly expressed their satisfaction and a desire to implement similar strategies in their teaching.

4. Conclusions

Science, engineering and mathematics fields have made a tremendous contribution in the design, development, utilization, and comprehension of the advanced technology driven world that we live in today. Capital investments of the future will be where the “smart” and “technologically proficient” people are. K-12 education plays a crucial role in providing the foundation for developing the workforce of the future. In the past “engineering/technology” fields had a weak interface with the K-12 system in the United States. The new “Technology Education” paradigm endeavors to remedy this and develop a technologically literate citizenry that understands and values economic ramifications of a comprehensive STEM education in the K-12 system and beyond. Engineering/Technology professionals and educators will have an active role to play to accelerate the speed of adoption of this new framework in K-12 system which has always struggled to legitimize technology education for all ^[12, 24].

Platforms such as the PSTP and its emphasis on STEM teacher preparation in the minority community are in a unique position to address the social implications of this comprehensive K-12 STEM education endeavor. Unless careful attention is paid to level the playing field, as K-12 systems adopt the new standards of “technology education”

which is shifting its attention from “industrial arts” and “vocational technology” to “pre-engineering”, a large number of people may be left far behind. It is therefore imperative for the new STEM teachers who will take up assignments in the poorer school districts in the underrepresented communities to fully understand the importance and the implications of this new paradigm. These new generation of teachers will also need to have a proper comprehension of the socio-economic forces that are driving the reform efforts in K-12 STEM education, so as to effectively serve their clientele.

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