Pre-Engineering Education and the STEM Career Expressway

John W. Hansen

Center for Technology Literacy
University of Houston

Abstract

This project describes the statewide activities of the University of Houston's Center for Technology Literacy to transform Technology Education in 6 – 12 public schools into the *Science, Technology, Engineering, and Mathematics (STEM) Career Expressway*. The *STEM Career Expressway* represents the integration of the physical sciences, mathematics, information technology, communications, design technology (engineering), the social sciences, and the technological systems. Through an integrated instructional design process the *STEM Career Expressway* equips students with the science, technology, engineering, and mathematics knowledge and skills required to prepare for high skill, high wage, and high demand majors and careers.

Introduction

Technology Education, as the academic subject area responsible for developing the technological literacy of Texas' children, has a unique mission that goes beyond the preparation of students to enter the workforce. Success in the 21st century will depend on our students' abilities to use, manage, design, and evaluate technology that fosters sustainable economic growth. It is much more than how to use this or that machine, tool, or software. As such, Technology Education does not focus on the specific skills of career preparation. Technological literacy is essential for all Americans, regardless of the careers, professions, and majors they select[1]. Up until now, the role of Technology Education within Career and Technology Education has been ill-defined and misunderstood by school administrators, parents, students, higher education institutions, and the teachers themselves. As a result, instructional activities in the technology classroom typically, (1) focus on hands-on activities related to tools and materials, (2) do not integrate or support the core academic subjects, and (3) do not use rigorous authentic assessments that ensure progress towards meeting course standards[2]. The needs and goals of the state clearly indicate that Texas Technology Education must assume a new and relevant role in preparing the youth of Texas for careers in a technologically prolific and dependent economy[3, 4].

This project will establish Technology Education's position in public education as the *Science, Technology, Engineering, and Mathematics Career Expressway*. The *STEM Career Expressway* will facilitate the transformation of Technology Education from an industrial tool-based

curriculum to one that equips students with the science, technology, engineering, and mathematics knowledge and skills required to pursue high skill, high wage, and high demand careers.

The *STEM Career Expressway* represents the integration of the physical sciences, mathematics, information technology, communications, design technology (engineering), the social sciences, and the technological systems. Through an integrated instructional design process these areas can support rigorous student achievement. The *STEM Career Expressway* can be supported with the recently approved teacher certification in Science, Mathematics, and Engineering for improving the number of students seeking careers in the sciences, technology, engineering, and mathematics.

The strategies to address the statewide objectives for this project are to:

S1. Develop and promote a *Science, Technology, Engineering, and Mathematics Career Expressway*.
S2. Revise and support the following courses: (1) Technology Education, (2) Technology Systems, and (3) Engineering Principles so that they represent the model for future Technology Education courses to support the *STEM Career Expressway*.
S3. Provide professional development through on-line, conferences, workshops, and seminars for preparing teachers to teach in the *STEM Career Expressway*.
S4. Promote robotics education as a formal and informal learning program that supports the *STEM Career Expressway*.
S5. Revise the Technology Education web portal (www.texastechnology.com) through the revision of existing materials to support the *STEM Career Expressway*.
S6. Promote Project Lead The Way as a pre-engineering initiative to support the *STEM Career Expressway*.
S7. Create an assessment team that will review and revise all existing and new materials to include assessments that measure a student's progress in STEM.

Strategy Descriptions and Rationale

S1. Develop and promote a Science, Technology, Engineering, and Mathematics (STEM) Career Expressway.
Rationale: This project proposes to establish Technology Education's position in public education as the *Science, Technology, Engineering, and Mathematics Career Expressway*. The *STEM Career Expressway* will facilitate the transformation of Technology Education from an industrial tool-based curriculum to one that equips students with the science, technology, engineering, and mathematics knowledge and skills required to pursue high skill, high wage, and high demand careers.

Career pathways[5] are broad areas of study which allow students to change their postsecondary focus as new knowledge, skills and experiences are acquired. Pathways provide students with an area of focus in school that are linked to occupational clusters. A career pathway is a fairly well prescribed description of a specific path that provides the details (skill expectations, course requirements, majors, etc.) to reach occupational destinations that are similar in knowledge and skill requirements. The career pathway model

is appropriate for most of the Career and Technology Education content areas, but not Technology Education, since its philosophical foundation is directed towards general education goals. The *STEM Career Expressway*, created by the author, is an emerging model for Technology Education. The expressway, composed of multiple lanes of study, is the route taken as one begins the search for a career. As students develop their interests, they leave the expressway and move onto their career pathway and focus on the specifics of the career. Traveling on the *STEM Career Expressway*, students change lanes as their interests change and they explore the variety of careers open to them in science, technology, engineering, and mathematics. Simultaneously, their core academic knowledge and skills are enhanced and applied through a highly integrated curriculum.

The development, definition, dissemination, and adoption of the *STEM Career Expressway* is the single most important strategy of this project because of its ability to position Technology Education as an integral component of public education for preparing our state's workforce and its ability to integrate and support the core academic subjects into the curriculum. Many students are advised into engineering and technology programs simply because they have high grades in their science and mathematics courses. With national retention rates in colleges of engineering remaining around 45%, this strategy has not been successful. Science, technology, engineering, and mathematics colleges need students who are more capable, better prepared, more diverse, and more informed about their career choices. The *STEM Career Expressway* integrates the various core academic areas with pre-engineering education to prepare students to pursue STEM careers.

Plan, method, and techniques: A development and advisory *STEM Career Expressway* board will be created to, first, create and articulate the model. Secondly, they will be responsible for overseeing and advising the implementation of this project. Once the model is created, materials will be developed and disseminated throughout the state to various audiences. Once the model is developed, the board will review the project activities on a quarterly basis to ensure adherence to the project objectives and timelines. The board will serve as the statewide advisory board to advise the Technology Education Program Director and the Center for Technology Literacy about the current and future needs, direction, activities, and support of Technology Education in Texas.

S2. Revise and support the following courses: (1) Technology Education, (2) Technology Systems, and (3) Engineering Principles so that they represent the curriculum model for future Technology Education courses to support the *STEM Career Expressway*.

Rationale: These courses were selected for revision because they are the entry points into the study of technology for middle and high school students. The middle school course, Technology Education, had a 2002 - 2003 enrollment of 35,776 students, representing 71% of the total middle school enrollment. Technology Systems and Engineering Principles' 2002 - 2003 enrollment represented 41% of the total first year high school enrollment. As the highest enrollment courses in Technology Education[7], they are prime candidates for a course redesign that ensures they are rigorous, career relevant, support the *STEM Career Expressway*, utilize authentic assessment techniques, and contribute to the completion of core

academic standards[8]. These courses will serve as the benchmark for how future courses will be created and/or revised.

Plan, method, and techniques: Teams will be organized to redesign each of the courses to align with the *STEM Career Expressway* model. Writing teams will be composed of individuals teaching in the STEM areas. The scope and activities of the redesign will be defined and directed by the project staff. While most of the work will be conducted "virtually," periodic team meetings will be held to foster the collaboration that must occur for the interdisciplinary efforts to be effective. The work of the teams will be reviewed by the project staff and the *STEM Career Expressway* advisory board. Instructional and learning activities will go through a formative assessment process to ensure that the materials meet their objectives, foster and assess STEM learning, and are flexible enough to be implemented in various school settings. The formative assessment will be conducted as the materials are developed in various schools in Texas.

Workshops will be developed and implemented by the project staff to assist schools and teachers with the implementation of the new courses. These workshops will be conducted throughout the state as they are requested by the school districts. They will also be offered at the 2005 Technology Education Professional Development Conference.

S3. Provide professional development through on-line, conferences, workshops, and seminars for preparing teachers to teach in the *STEM Career Expressway*.

Rationale: Multiple venues for professional development need to be established if teachers are to be properly supported in teaching in the *STEM Career Expressway*. Instruction in the classroom must be supported by professional development activities that support new content, technologies, and pedagogy[4, 5]. Often, teachers are not trained on how to collaboratively work with the core academic teachers to inform their instruction. The *STEM Career Expressway* model requires technology teachers to acquire new skills in instructional development, assessment, and student advisement.

Plan, method, and techniques: The project has acquired on-line courseware that supports the *STEM Career Expressway* and the Texas Essential Knowledge and Skills. Access to the materials will be free to Texas teachers from home or school. Individual workshops and in-service training will be created and offered based on the local needs of the school district. Specialized workshops will be available as a tactic for being more responsive to the needs of schools throughout the state as the *STEM Career Expressway* builds momentum. Conference planning will incorporate the *STEM Career Expressway* as its theme and workshops, seminars, and presentations will reinforce the theme. Teachers will be selected and trained as liaisons between the project and their schools and districts. Essentially, a network of trained teachers will be available to assist school districts in the implementation of the *STEM Career Expressway*.

S4. Promote robotics education as a formal and informal learning program that supports the *STEM Career Expressway*.

Rationale: Robotics education has a unique role to play in integrating and applying STEM concepts to real dynamic problems. Research has shown that academics can be reinforced through the proper selection of formal and informal learning opportunities[7, 9]. Many science and technology teachers are already involved in robotic competitions such as FIRST, BEST, FIRST LEGO League, and BotBall. Yet, there is virtually no measurement of the learning outcomes of these competitive events. The project proposes to develop opportunities and materials to support authentic learning and assessment in robotics education as a means to demonstrate how core academics and engineering and technology concepts can be integrated to improve learning.

Plan, method, and techniques:
Formal robotics education activities include but are not limited to creating an outreach program that supports FIRST LEGO and BotBall robotics in the classroom. Activities will employ the engineering design process by having students create authentic, real world simulations. Sample projects would be (1) Firefighting: Students would build and program robots that would navigate a maze, with a light representing the fire, to put out the fire; (2) Handicap door system: Students would design, construct, and program devices that would allow the simulation of a door opening process for handicapped people.

Informal robotics education activities would include but not be limited to promoting FIRST LEGO robotic education organizations and competitions. Workshops for teachers would be provided to assist them in teaching robotics, programming the robotic devices, and managing their school's robotic teams and competitions.

The project will also conduct research on the effectiveness of robotics education as a learning program for improving in the core academic areas as well as engineering and technology. The research plan will be a qualitative study with appropriate quantitative information to enhance the study.

S5. Revise the Technology Education web portal (www.texastechnology.com) through the revision of existing materials to support the *STEM Career Expressway*.

Rationale: The materials currently available to Texas technology teachers were prepared to support the implementation and support of the Technology Education TEKS. Having served their purpose, they should be revised to reflect the transition to the *STEM Career Expressway* model. New technologies and new learning paradigms are emerging that can significantly improve instruction, learning, and career choices[8]. As a result, we believe these materials should be evaluated based on a rigorous STEM rubric to determine if they facilitate progress in STEM education. Materials that do not meet these standards will be removed from circulation and professional development activities will no longer be offered to support these materials. With the creation of the *STEM Career Expressway*, the website will be revised to reflect a reorganization of its content. The goal is to make the website more relevant to science, mathematics, and social studies teachers as well as the technology teachers.

Plan, method, and techniques: A review rubric will be developed by the project staff to identify materials that need to be removed from circulation or that could be revised to

support the *STEM Career Expressway*. The review will be conducted by the CTL staff. The website will be redesigned to included sections that support the integration of core academic areas into Technology Education. All materials developed by the project are available for free downloading from the website.

S6. Promote Project Lead The Way as a pre-engineering initiative to support the *STEM Career Expressway*.

Rationale: Project Lead The Way (PLTW) is a national non-profit organization established to help schools give students the knowledge they need to excel in high tech fields. There are currently 1009 schools across the nation participating in the PLTW program. Studies of the PLTW curriculum have proven that PLTW students become the kind of prepared, competent, high-tech employees U.S. industry needs to stay competitive in the global market. The Project Lead The Way program provides students a reality-based, hands-on learning environment. Students participating in Project Lead The Way have the ability to enter and complete post-secondary studies in science, mathematics, engineering and technology. There are currently 50 middle and high schools in Texas that are following the PLTW curriculum model (Texas ranks fourth in the nation). As a result of prior activities, the CTL Director has developed a strong working relationship with the Texas Project Lead The Way schools. The teachers and administrators have come to rely on the Center for Technology Literacy for needed PLTW information and support.

Plan, method, and techniques: This strategy will be accomplished through an extensive dissemination and support program. Through presentations at various administrator and teacher conferences throughout the year, the appropriate decision-makers at the local level will gain a better understanding of how PLTW can meet their district's needs. Brochures will be developed and disseminated at regular intervals to support a better understanding of pre-engineering education in Texas. In addition to a counselor's conference, the project anticipates organizing local meetings with administrators to provide a more efficient mechanism for answering PLTW related questions on the deployment of PLTW and how the CTL supports PLTW training.

Teacher training efforts are focused on the PLTW Summer Training Institute held at the University of Houston in June. Schools adopting PLTW will be able to send their teachers to the two week training institute. Update training, conducted asynchronously, will be organized by PLTW and supported by the CTL. In addition, PLTW Texas is pioneering the creation of a support network of PLTW master teachers to assist and mentor new PLTW through their first year teaching the new PLTW course.

S7. Create an assessment team that will review and revise all existing and new materials to include assessments that measure a student's progress in STEM.

Rationale: Assessment in Technology Education has not typically incorporated a clear understanding of the learner outcomes as they relate to technological literacy, pre-engineering education, and the core academics. To ensure that Technology Education

programs are contributing to students' progress towards STEM careers, relevant and rigorous assessments should be developed.

Plan, method, and techniques: An assessment team will be organized that will develop a model for incorporating core academic, technological literacy, and pre-engineering knowledge and skills into existing course materials[7, 10]. The assessment team will be responsible for reviewing all currently developed Technology Education materials to ensure they adhere to the assessment model they developed. New materials will also be subjected to this review process. In addition, the team will develop a training program that will allow them to become assessment facilitators in their schools and districts. The team will also assist in the rewriting of the Technology Education, Technology Systems, and Engineering Principles courses to ensure they meet the standards the team has developed.

Conclusion

This 15-month project seeks to shift the efforts of the State's technology education teachers from its traditional industrial tools and materials emphasis to one that prepares students for future studies in the STEM career cluster. The comprehensive nature of the project should significantly impact the professional practice of teachers and facilitate the development of a sustainable and diverse flow of high school students into STEM postsecondary studies.

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Biographical Sketch

JOHN W. HANSEN

John W. Hansen is Chair of the Department of Information and Logistics Technology and is Executive Director of the Center for Technology Literacy at the University of Houston. He holds a BA and MA in Industrial Arts from California State University, Fresno and a Ph.D. in Vocational and Technical Education from the University of Minnesota. His research interests include technology and pre-engineering education as they relate to the development of creativity and inventive capabilities of children.