Delivering Integrative Science Technology Engineering and Mathematics [STEM] Education: Technology Teachers' Experiences in a Summer Camp

James S. Carlson[1], Hyuksoo Kwon[2]

[1,2]Technology Education/Integrative STEM Education
Virginia Polytechnic Institute and State University
Blacksburg VA 24060, USA
carlsonj@vt.edu[1], kwon06@vt.edu[2]

Abstract

Traditionally, school curricula has been largely based on the concept that instruction should be separated into distinct subjects for ease of understanding and later reassembled when complex applications are required (Wicklein and Schell, 1995). The functions of the disciplines of STEM identify the need for a new approach to teaching using an integrative approach to education, research and practice. In order to support an integrative STEM education, stakeholders in education must work together towards a common end goal of teaching science, technology, engineering, and mathematics in a holistic way. Without consideration of how these disciplines work together for the advancement of humanity, we would not have the deep knowledge of nature that it has today. The purpose of this paper was to reflect on an Integrative STEM education by sharing technology teachers' experience in a summer camp for the 7th and 8th grade students, "Imagination", planned by Virginia Tech. To accomplish the purpose, the researchers reviewed relevant literature associated with the integrative efforts in the field of technology education, described the program lessons, and particularly specified researchers' experience of delivering a hands-on activity in construction technology area. Through researchers' participation in the "Imagination Program" we found one way to be purposeful in designing activities for our classroom. By examining other disciplines standards and how they compliment each other we can start to integrate content that specifically addresses the needs of the students.

Introduction

Traditionally, school curricula has been largely based on the concept that instruction should be separated into distinct subjects for ease of understanding and later reassembled when complex applications are required (Wicklein & Schell, 1995). Professional literature has long supported the idea of integrating traditional academic material with technology material (Gray, 1991; LaPorte & Sanders, 1995; Zuga, 2000). The history of integrative approach in technology education has supported the major spirit of STEM education from 1808 to 1815. Napoleon's School for Industry was one of the earliest attempts to integrate technology with science and mathematics in a school (Pannabecker, 2002). The integration of technology with mathematics and science has been the subject of research in technology education and technology educators have recognized integration needs of mathematics, science, and technology education (TSM) historically. LaPorte and Sanders (1995) provided some theoretical background for the benefit of integrative education in Technology Education in the form of TSM (pp. 179-219). As Zuga (2000) argued, "in a Technology Education laboratory, including the scientific inquiry constructs and mathematical principles related to Technology Education content and activities strengthens the connections that students can make in all three subjects [science, mathematics, and technology] and in their integration" (p. 226). It is possible that technological content and/or technological process based on hands-on activities play a significant role in integrating and connecting science and mathematics. This study employs the definition of STEM education as below.

Integrative STEM Education

> "An integrative curriculum model that seeks to make connections among Science, Technology, Engineering, and Mathematics (STEM) disciplines through the use of open-ended and real world problems." (Drake, S., and Burns, R. 2004, VT Technology Education. 2006, Sanders 2006)

The authors of this paper are current Ph.D. students in technology education that focuses on integrative STEM education. The question that keeps on surfacing in our classes is "How do we implement integrative STEM education?" Currently, there is not a set curriculum for integrative STEM education, but there are some examples of integrative approaches to integrative teaching that can be investigated. Over the summer of 2007 the authors of this paper had the unique opportunity to work with engineering in their approach to an integrative STEM education.
The purpose of this paper is to share that experience and how the authors approached designing and implementing an integrative STEM education lesson.

Program Identification

Program Description

The main philosophy of "Imagination" program was to introduce the exciting and fun activities to rising 7th or 8th graders in Southwestern Virginia. They explored the world of technology, engineering, and science not by watching but by doing. The program offered students interested in engineering to take part in engineering, science, and mathematics activities in order to explore the world of STEM other than in their a traditional education classroom. The authors participated in the three-week summer camp program as an instructors and help support the deliver of other instructor's activities throughout the day. This provided the authors with an opportunity to observe and participate with other educators in delivering integrated activities. The instructor group consisted of different backgrounds: Undergraduate students (engineering and science), graduate students (technology education, science, and engineering), and professors. Basically, the composition of the instructor group represented the diverse disciplines of STEM.

Program Lessons Descriptions

There were a variety of lessons for hands-on activities in this program, representing one or more disciplines of STEM. Described below are some of the lessons that were delivered during the program. Many of these lessons are lesson technology educators have taught for in their own classrooms. The uniqueness of the "Imagination Program" is that it approaches these lessons from the viewpoint of the other disciplines.

Lego Mind Storm: Using Lego Mindstorms NXT robots, the students participated in the problem solving activity of "Transferring Two Ducks from Duck Pond". The problem that the student had to solve was the transfer two ducks models into the designated target place. The students were instructed to use the NXT robots as a major transportation vehicle. One instructor demonstrated the basic programming commands and operation. The students had two hours to learn the operation of these robots and solve the problem. At the conclusion of the activity each team presented their performance with a real operational demonstration to other teams and instructors.
Silly Putty: This was a one-hour hands-on activity. The instructor was a professor in the chemical engineering department at Virginia Tech. The students made funny putty with very familiar ingredients: Elmer's glue, water, and Borax solution. Even though it was a simple process, the participants discussed the material's characteristics and the safety rules for the hands-on activity. The activity engaged the student by having them make their own silly putty and apply what they learn in the discussion.
Rocketry: The instructor engaged the students in a thirty-minute fundamental lecture and discussion on the principles of Aerodynamics. The participants then made their individual rockets. Later in the week the students launched their rockets and participated in a competition of whose rocket obtained the highest altitude.
Crystal Radio: A graduate instructor majoring in the Electrical Engineering field delivered this hands-on activity. This radio did not require any battery power and could detect five radio-broadcasting stations. This activity consisted of thirty-minute lecture and discussion about radio, and two-hour hands-on activity. The students they were allowed to connect their radio to a large outside antenna to test their radio.
Coasters: This was a team project. The students were instructed to make a roller coaster under several conditions. Using basic material provided and introduction, the students created a variety of coasters and demonstrated them in front of other teams and instructors. This activity emphasized on design and teamwork to produce a high performance roller coaster.

Spaghetti Bridge: Using only spaghetti and epoxy (or paper tape), the students constructed a bridge that would span a limited width and could suspend a certain weight. Also, it had a designing, constructing, and testing process. The discussion during this activity focused on geometric shapes in structures.

Egg Drop: This activity was to create a safe vehicle for their respective passengers (the eggs) to travel from the bridge to the ground below. The student had just three minutes for designing and creating their vehicles. They tested their vehicles. The team who had a successful (safe) testing with the lowest price' material was the winner at that project.

Index Card: This problem solving activity engaged student by constructing a strong structure with only three index cards, twelve inches tape and string. The structure should sustain the weight of as many books as possible. This lesson built from the other lessons of the week by having student reflect on what they had learned in other activities and apply it to the construction of their index card structure.

Authors Participation

We were charged to plan an activity for the group that focused on construction technologies. The activity that we choose to implement was the index card structure activity. The problem was that our lesson only as it was planned already only focused on meeting ITEA standards. Our solution was to redesign this lesson and to plan an activity to not only addresses ITEA standards but the standards of other disciplines as well. We felt that it should be our goal as integrative STEM technology educators to provide the students with a lesson were the goals are only technology literacy but STEM literacy as well.

In order to prepare for this lesson we knew the ITEA standards that our activity addressed but we did not know if our lesson addressed any of the other standers in the other disciplines. Our other dilemma was we did not just want to identify a standard in the other disciplines that fit into the activity we have already designed we wanted our activity to purposefully address the other standards. Our first step was to examine the other disciplines standards. Science and math have standards much like the ITEA standards. These standards identify what students should know at what grade levels. Engineering currently does not have these sets of standards. The National Science Education Standards (1996) and the Principles and Standards for school Mathematics (2000) were used for our activity design. Our next step in this process was to identify what standards complimented each other in 7th and 8th grade. Table 1 identifies what standards we decided to address in our activity. At this point were where able to verify that our lesson could still be used to deliver discipline and grade appropriate content.

Lesson Description

The index card structure lesson provides students with an introduction to forces that are acting on materials within structures. The forces students were exposed to in this lesson were compression, tension, and torsion, which are all factors that affect vertical structures. The goal of the lesson was for students to explain the forces acting on their structures and why failed under the weight of the textbooks. The students were supplied with 12'' of masking tape, three 3x5 index cards, a ruler, and a pair of scissors. They were then were engaged in a discussion on the forces and provided with the vocabulary that they were expected to use during the lesson. After the discussion the students were divided into groups and instructed to design a structure that can hold the most weight. The structures were then tested and students were asked to present to the groups why their structures failed. While designing the index card structure, the authors encouraged students to solve their problems using testing and revising the structures.

Table 1

Integrated Standards

Discipline	Publication	Standard (Grades)
Science	The National Science Education Standards (1996)	Science and Technology (5-8) ✓ Abilities of technological design Physical Science (5-8) ✓ Motions and forces
Technology	Standards for technological literacy: Content for the study of technology(2000)	Connections between Technology and Other Subjects (6-8) ✓ Knowledge from other fields of study and technology Attributes of Design & Engineering Design (6-8) ✓ There is no perfect design/Requirements ✓ Brainstorming Apply the Design Process (6-8) ✓ Identify criteria and constraints ✓ Model a solution to a problem ✓ Test and evaluate Construction Technologies ✓ Construction designs/Purpose of structures
Mathematics	Principles and standards for school mathematics (2000)	Geometry (6-8) ✓ Recognize and apply geometric ideas and relationships in areas outside the ✓ mathematics classroom, such as art, science, and everyday life Measurement (6-8) ✓ Solve problems involving scale factors, using ratio and proportion Connections (6-8) ✓ Recognize and apply mathematics in context outside of mathematics

Final Thoughts

The purpose of this paper was to reflect on an Integrative STEM Education experience. In reflection on our experience the authors of this paper recognized that in order to support an integrative STEM Education environment we have to have knowledge of the objectives the other disciplines in STEM. In Technology Education it has been habit to say that we teach science and math, but the question becomes is it purposeful in design. Through our participation in the “Imagination Program” we found one way to be purposeful in designing activities for our classroom. By examining other disciplines standards and how they compliment each other we can integrate purposefully content that specifically address the needs of the student.

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