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12. A CULTURAL PERSPECTIVE OF TEACHING AND LEARNING ETE IN A DIGITALLY CONNECTED WORLD

INTRODUCTION

The past millennium has brought forth unprecedented advancements in engineering and technology. Microchips have been invented and shrunk to the size of a pinhead, man has walked on the moon, great rivers have been dammed for irrigation, the Internet connects the globe through social networking, nanotechnology brings medical breakthroughs and Global Positioning Satellites (GPS) guide us to our destination. These advancements shape our social systems, our view of the world, how we interact with fellow humans and the quality of life. Each country's culture and how they live has been influenced by engineering and technological advancements, which continue to mold culture and influence a new generation of students. Yet, in many ways, educational systems across the globe have not integrated and joined the technological cultural influences of students with the technological advancements shaping the world.

This chapter looks at four key questions and examines how ETE is influenced by third millennial culture and how culture is influenced by technology:

- How is culture influenced by technology?
- What is the technology of the third millennium?
- What are the implications of integrating third millennial culture into educational curriculum?
- What are some examples currently employed of using third millennial technologies for education in ETE?

HISTORY LESSON

The anecdote below originally published in *Learning in 3D* by Kapp and O'Driscoll (2010) contrasts the difference between technological advancements in standards of living and culture, and the current educational system dominating the education of international youth.

The Smith family was excited about their visit to the Lost Colony in Manteo, North Carolina. Megan, just turning seven, had learned all about how 120 brave men, women and children established the first English settlement on Roanoke Island in 1587. Three years later, when Governor John White returned, the colony had

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vanished, leaving only one clue as to their whereabouts the word "Croatoan" carved on a post.

As they entered the Lost Colony, Megan was eager to solve the mystery of how they had vanished. In visiting the first building, brimming with curiosity, Megan asked *"Mommy, Mommy what did they do in here?" "This is a blacksmith's shop,"* answered her mother. *"This is where he made tools and horseshoes. That is called an anvil, and the blacksmith used it to shape the hot metal from the fire over there." What did horses need shoes for Mommy?* Asked Megan. *"Well back then people used horses to get around… they did not have cars back then," answered Mom. "But Mommy, horses poop and they go very slow, it must have been hard to get around back then… I am glad we have our minivan with a DVD player in it so I can watch movies when we travel."*

They strolled into the next building. Mom braced herself for the next barrage of questions. "*Mommy, Mommy, what did they do in here?*" asked Megan*. "Well this is where they made clothes Megan… Daddy will explain it to you, I need to change Connor's diaper." "Well Megan, over here is where they sheared the sheep to get wool to make clothes,"* said Dad. *"Ouch. Did that hurt the sheep Daddy?"* Megan asked, quite concerned. "*Not at all,*" said Dad. *"Then they took the wool and put it into this spinner to make yarn, they then took the yarn and put it on this machine called a loom to make cloth that they used to make clothes using this sewing machine over here." Wow*, said Megan*, "that looks like a lot of work just to get some clothes. I am glad that all we have to do is hop in the minivan and go to Wal-Mart when I need a new Dora t-shirt."*

As they went into the next building, Dad was prepared. Before she even asked, he began, *"Now Megan, this is a bakery. Over here is where they blended ingredients to make the dough. Over here is where they rolled the dough into loaves that they then put into this oven to cook."* Looking very concerned, Megan asked, *"Wait a minute Dad, don't tell me they didn't have Wonderbread back then?.... No wonder this became a Lost Colony….How can anyone go a day without Wonderbread … Wait, I figured out the Mystery Dad! Maybe Croatoan is olde English for 'We Need Wonderbread!'"*

As they waited for Mommy and Connor to come back from the restroom, Megan and her dad chatted about how things have really changed for the better over the last four centuries. Then they all headed towards a larger building over by the chapel. As soon as they entered the room, Megan didn't need to ask a single question. She spoke immediately, *"Mommy, Daddy, don't tell me, don't tell me… I know what this is… It is a classroom. This is where we go to learn."*

TECHNOLOGY'S RELATIONSHIP TO CULTURE

As the story above poignantly illustrates, a large portion of a civilization's culture is defined by its technology. Historical periods are often named for the influence of technology on the period. The Stone Age, Bronze Age, Iron Age, Industrial Revolution and Information Age are all closely related to the influence a particular technology or group of technologies had on livelihood, people and governments during that period in history. As technology evolves and changes over time, a culture will either change with the technology or disappear, or, in some rare cases, will shun the technology and remain isolated from the rest of the world.

One large group that has shunned technology and remained largely unchanged throughout hundreds of years is the Amish. This religious group, founded in the 1600s and living in the Eastern United States, refuses to incorporate modern technologies into their culture and way of life. They use horses to plow fields, bicycles for transportation and do not use electricity in their homes. The group has made a concentrated effort to maintain a culture untouched by technological advancements. Other groups are simply too isolated to feel the impact of technology. The Ayoreo-Totobiegosode Indians who live in a dense forest region stretching from Paraguay to Bolivia and Argentina are a group that has not adopted modern technologies because of their isolation and the remoteness of their region (Ayoreo, 2009).

What we can learn from these two examples is that isolating individuals from technology leads to a point of technological stagnation. While these are extreme examples, it is true that groups become isolated from technological advancements either through conscious efforts or neglect. As ETE educators, we cannot afford to allow our students to become isolated from the technologies used in our field nor can we isolate ourselves from the technology used daily by students in our classrooms. We risk the technological isolation of the Amish or the Avoreo-Totbiegosode Indians if we fail to integrate third millennial technology culture into our ETE curriculum.

Understanding the intricate relationship between culture and technology is critical in understanding how culture and technology support each other in the education of the youth of a culture. In Nieto's book *Affirming Diversity* (2004), the author describes culture as "The ever-changing values, tradition, social and political relationships and worldview created and shared by a group of people bound together by a combination of factors that can include a common history, geographic location, langaugae, social class, and/or religion, and how these are transformed by those who share them." To foster learning in the context of culture, we must understand that culture changes as the values, social relationships and worldviews of individuals change, and part of that change is a direct result of the influence of technology. Where is the change in a society more rapid or far-reaching than in the realm of technology? When groups fail to change their culture with the technology, they risk isolation.

Therefore, when examining how to foster human development through engineering and technology education, the cultural influences of teachers, administators and students must all be considered, with a special emphais on the culture surrounding the students. We know from a variety of research (Delpit, 1995; Gay, 2000; Nieto, 2004: Villegas & Lucas, 2002) that successful schools place their students' cultures at the center of their missions and curriculum. For ETE to be successful, elements of the culture surrounding the third millennium students must be carefully considered and integrated into the curriculum.

In the science discipline, great efforts have been made to shift schooling from the delivery of subject matter to inquiry-based learning. Technology education also underwent significant changes in many countries over the past few decades both in terms of content and instructional methods. Early curricula focused on hands-on activities primarily based on the apprentice/journeyman model, which was how early engineers and technicians were trained. As Hacker and Kiggens point out in Chapter 14, some teachers, trained as industrial arts teachers, are still teaching as they were taught; despite the overarching need for a technologically literate student body and workforce, some school programs are still rooted in crafts teaching.

But while some instructors remain rooted in tradition, other movements within the ETE educational environment have focused more on the abstract or conceptual basis of the fields of engineering and technology and less on the roots of hands-on activities. Curriculum materials have become increasingly more focused on the abstract concepts related to the field. The instructional emphasis has grown more conceptual and abstract with less focus on traditional skills such as craftsmanship and hands-on activities while still not fully addressing the technological needs of students and the field.

This is best highlighted by de Vries, who points out in Chapter 5 that as an educational structure grew around the ETE curriculum several different methodologies were advocated in the literature and applied for teaching concepts associated with engineering and technology. De Vries describes that early approaches focused on teaching abstract concepts at the beginning of an educational sequence. Eventually, this approach yielded to a movement in which it was hoped that students would be able to 'transfer' engineering and technological knowledge to other situations thorough a generalization process. And currently a more complicated approach is advocated in which the student is taken through a variety of situations, or contexts, in which different manifestations of the same general concepts are present. The idea is that the learner gradually begins to understand the communalities between the manifestations and acquires the general concept. All of these efforts mean that a standardized pedagogical base for constructing ETE curriculum has not yet been developed since the instructional approach and methods keep shifting.

Although the objectives of these reforms were only partially accomplished, we now have an opportunity to learn from experience and to introduce educational reforms that combine design-based methods, constructivist pedagogy and the technological acumen of the third millennium students to create instruction that is meaningful, impactful and capable of engaging students both within and outside of the four walls of the traditional classroom. In the past half century, the educational literature and research have emphasized the advantages of constructivist pedagogy over traditional teaching. We can assist students in constructing artifacts and systems aimed at solving practical needs and problems within the field.

We can't ignore the digitally connected culture or the reality of these digitally savvy youngsters. Instead, we need to examine their culture and integrate parts of this culture into our educational approach. Adopting all of their cultural nuances and quirks into a curriculum is just as ill-advised as the whole-scale rejection and dismissal of their culture and digital acumen. We, as educators, must strike the right balance of embracing elements of their culture with the instructional needs and requirements of engineering and technology fields.

TECHNOLOGY, CULTURAL INFLUENCES AND THE TEACHER

The influence of the third millennial culture must reflect more than content; it must impact methodology, approach and instructional activities. Yet, even today, instructional methodologies are heavily influenced by the instructional models and cultural influences of teachers and administrators, not the students. Much of the culture surrounding schools is based on the ideas, culture and influences of teachers and administrators during their formative years. As Knowles (1992) indicates, formative experiences of pre-service and beginning teachers influence the ways they think about teaching and subsequently their actions in the classroom.

Teachers teach in ways similar to how they experienced teaching during their own schooling and hold beliefs based on those experiences (Borko & Putnam, 1996; Thompson, 1992). Today's ETE educators grew up in a technological culture considerably different than the culture of their students, and they often have trouble leveraging the tools of the current culture. It can be difficult for teachers to adapt to technological influences that they themselves have not experienced during their formative years.

Instructors tend to teach in the same style and format that they have been taught. For the current generation of teachers, this included a linear step-by-step approach involving little technology in the classroom. In terms of pedagogy, much of the efforts during the current generation of a teacher's formative years were focused on the students as empty vessels to be filled with the wisdom of the instructor. Students were placed in rows of seats, and the teacher at the front of the room held all of the knowledge that they presented to students, who were assigned to memorize and repeat the information provided to them by their teachers.

In terms of technology, computers and even calculators were not available for much of the educational life of teachers today. Many current teachers remember using slide rulers instead of calculators. Affordable hand-held calculators didn't become widely available until the late 1970s and not until much later in many cultures and countries. While educational reforms since those formative years have had some impact, the overall effect has not been as widespread as expected.

As a result, the instructional paradigms employed for engineering and technology education across the globe have not fully embraced the technologies of video games, Internet, social media or mobile devices, or the associated teaching methodologies that must accompany the technology tools. Many teachers are unfamiliar with the opportunities afforded by technology-mediated methodologies and many curricula do not leverage the digital connectedness of students. The result is that technology tools are not fully utilized in the educational curriculum for engineering and technology education, and an exploratory, constructivist approach is not widely adopted.

The basic instructional paradigm for teaching students engineering and technology has not adapted to the explosive use of technology in the third millennial culture. This is not to say that technology tools haven't been introduced in schools; they have. But simply adding computers to a traditional classroom without a corresponding change in instructional delivery or strategy doesn't work. It highlights the disconnection between how third millennium students leverage technology for day-to-day communications and interactions with limited use of the technology within academic environments. And adding technology hardware is not enough. The next wave in engineering and technology education is to leverage the connectivity of the third millennium and its aptitude for creating content to share with others via web-based networking tools.

THE CHANGING CULTURE OF THE THIRD MILLENNIUM

For students in the third millennium, the Internet has always existed, video games have progressed far beyond the 1972 launch of Pong, and "smartphones" have replaced "land lines" for person-to-person communication. Kids are growing up with cell phones, video games, Internet access and a culture that rewards creating digital networks and online content. Today, the video game market is larger than traditional entertainment media. In the United Kingdom, the video game market has surpassed cinema, recorded music and DVD sales to become the country's most profitable purchased entertainment market (Rosenberg, 2009). In the United States, 67% of households play computer or video games (Industry Facts, 2010).

And the third millennium generation is not just consumers of content. They are content creators. Many people in the third millennium engage in highly creative activities on social networking sites, with the National School Boards Association in their *Creating and Connecting Report* (2007) indicating that about 96% of those with online access undertake activities like chatting, text messaging, blogging and visiting online communities, such as Facebook and MySpace.

The most ubiquitous device of the third millennium around the world is the cell phone. The first commercially automated cellular network (the 1G generation) was launched in Japan by NTT in 1979, and cell phone networks in the early 1980s were launched in Denmark, Finland, Norway, Mexico, Great Britain, Sweden and the United States. Today, six in 10 people around the globe use a cell phone, which totals over 4.1 billion people (Beaumont, 2009) In Japan, 24% of all sixth-graders own a cell phone, while 45.9% of second-year students in junior high school own one and over 95% of eleventh-grade students have a cell phone (GSM Association, 2009). Korean youth are among the youngest to begin using cell phones. The more the parents emphasize education, the earlier their children get their first cell phone. Moreover, Korean youth are more likely to trust in new media than they would in traditional media sources (GSM Association, 2009). Additionally, the nature of cell phone usage has shifted from voice calls to text messaging; the average American cell phone subscriber now sends and receives more text messages than voice calls (Reardon, 2008), and one of the fastest growing uses of mobile devices is Internet access.

Meanwhile, the Internet itself has changed dramatically since its early inception. The Internet morphed from a static, one-way communication network into a dynamic platform for the exchange of ideas, concepts and innovation. Over 90% of all children aged 12–17 are on the Internet daily, and this use results in the creation of new content and the posting of new information by these young people and others (Macgill, 2007).

So many people are creating their own content that in 2006, *Time Magazine* named "You" the person of the year because, as they put it: You are the person of the year for "seizing the reins of the global media, for founding and framing the new digital democracy, for working for nothing and beating the pros at their own game" (Grossman, 2006). In other words, the honor was bestowed upon "You" for creating content and exchanging ideas in an open forum where one does not need special access or expensive equipment to distribute thoughts or ideas. The only access required to post information on the Internet is the ability to log on. The widespread use of social media and web-based applications is allowing increased communication among students and is fostering relationships, collaborative exercises and working together at an unprecedented rate.

IMPLICATIONS FOR ENGINEERING AND TECHNOLOGY EDUCATION

Society and culture are responding to the needs of youngsters in unprecedented ways. Marketers, advertisers, video game companies and electronics manufacturers are focusing their efforts on pleasing youngsters in terms of design, visual appeal and functionality of new technology. The third millennium generation is shaping society and culture more than in any other time. They continue to push consumer companies for more connectivity, more ways to create their own content and more access to information. They demand expanded communication channels through instant messaging applications, social networking sites and place-based interactions. The use of smartphones as a communication platform for texting and video chatting has increased as "connectedness" through technology becomes common practice around the world.

Video game companies have responded by creating multiplayer versions of their once solitary products. Playing a video game is no longer done alone or with one or two friends in the same room; games are played across the world with hundreds of players who never physically meet one another. The widely popular multiplayer role play game, World of Warcraft, has over 11.5 million subscribers worldwide and shows no signs of slowing growth (Blizzard Entertainment Press Release, 2008)

But the growth of online games is dwarfed by the number of people connecting through social networking sites. The social networking site, Facebook, has over 500 million active users, with 70% of these users being from outside the United States. In the third millennium, friends are being made over digital networks and kids who have met once keep in contact for years via updates to Facebook, MySpace or other social networking pages. And they stay active within their social networks: the average Facebook user has over 130 friends (connections), is connected to 80 community pages, groups and events, and creates 90 pieces of content each month (Facebook Press Room, 2010).

The implication for educators in the subject areas of engineering and technology is that the technologies employed by the third millennial generation to communicate and stay connected must be integrated into the ETE curriculum. The obligation of ETE professionals to leverage third millennium technologies is even higher than in other fields. The fields for which we prepare students routinely use technology for transactions, creating designs, crafting digital "what if scenarios" and to drive innovation and advancement. The engineering and technology disciplines would not exist without technology, and preparing students to enter these fields requires that they understand and appreciate how the technology functions and the thought behind its use.

We must prepare students to design systems and apply mathematical, scientific and technical skills to solve problems while employing professional judgment in balancing issues of costs, benefits, safety and quality. We must prepare students to use technology to connect with end-users of the products they design, to test software applications and to debug hardware. The explosive growth of social networking software, smartphone hardware and other technological advances mean that an entire new generation of students must be well-educated, not just in the use of these new technologies, but in their creation, maintenance and troubleshooting.

Students can't learn to troubleshoot, design and develop the technologies in which they are immersed unless we integrate them into our ETE curriculum. Integrating these technologies into various parts of the curriculum provides the opportunity for students to experience the design and development side of the technologies they take for granted to communicate and play.

Preparing students to enter engineering and technology disciplines requires teachers in engineering and technology disciplines use technology to reach the students. The teachers of these topics can benefit tremendously from the intelligent convergence of learning strategies, pedagogy and technology matched to the cultural sensibilities of the connected third millennial students.

If we systematically ignore the technological cultural influences of the third millennium and pretend that they don't exist, or continue educating these youngsters as we have been educated, we risk, at best, being ignored, and, at worst, not preparing them to deal with the realities of the digitally connected world of technology and engineering awaiting them when they complete their educational experience.

EXAMPLES OF THE USE OF NEW TECHNOLOGIES IN ENGINEERING AND TECHNOLOGY EDUCATION

Elements of the third millennial digital culture have specific and unique applications to engineering and technology education. Using three-dimensional animation software to teach object-oriented programming, games to teach engineering concepts and social media to connect students with professionals in the field are all ways of engaging third millennial students with the technologies they currently embrace. ETE educators have the opportunity to reach students through familiar technologies and to apply the natural problem-solving approach of video games and computer software in using a constructivist approach to provide third millennial students with the educational foundation they need to design, develop and troubleshoot future technological advancements they will encounter in the fields of engineering and technology.

The integration of technology and a constructivist approach into ETE education is critical as teachers should be providing the hands-on experience with technology and a chance for students to create content with the technology. In ETE, we must help students understand and become familiar with the technology by having them use the technology to learn about the technology—this approach, reinforced with sound constructivist pedagogy, will lay the foundation for success in ETE.

Educators can seize the tendencies of the third millennium students and leverage their understanding and comfort level with technology to create engaging ETE experiences. Currently, there are already several examples of organizations combining third millennial interest in technologies with engineering and technology topics.

In this section of the chapter, we examine several techniques used to converge third millennial technologies with pedagogy and answer the question "What are some examples currently employed in using third millennial technologies for education in ETE?" This section will discuss a number of projects and tools leveraging third millennial technologies to engage students in engineering and technology subjects. Tools explored include:

– Game design software
– Simulations
– Video games
– Social media
– Smartphones

Game Design Software

A method of helping students gain an understanding of design and programming, and the underlying logic is to have them develop their own code and practice applying programming concepts to their own projects. This approach can be focused on problem-solving and on building knowledge and skills through various programming approaches and considerations. One such example of using software to teach programming is a computer program called Alice.

Alice – Alice is a computer software program developed at Carnegie Mellon University designed to teach students computer programming in a 3D environment. [www.alice.org]. The software is freely available and was created to be a student's first exposure to object-oriented programming. It allows students to learn fundamental programming concepts in the context of creating animated movies and simple video games. With the software, 3D objects (e.g., people, animals and vehicles) populate a virtual world and students create a program to animate the objects.

In Alice's interactive interface, students drag and drop graphic tiles to create a program. Within Alice, the instructions correspond to standard statements in a production-oriented programming language, such as Java, C++ and C#. Alice allows students to gain immediate feedback on how their programs are running, enabling them to easily understand the relationship between the programming statements and the behavior of objects in their animation. By manipulating objects in their virtual world, students gain experience with all the programming constructs typically taught in an introductory programming course. Figure 1 shows the object-oriented code from the program used to make an ice skater move.

Unlike traditional programming languages that require users to follow a rigid syntax, Alice couples a drag-and-drop editor with characters and animated actions to provide an open-source, object-oriented programming environment. Alice offers two major advantages for students learning to program. First, the drag-and-drop interface provides a method of program construction that prevents users from making

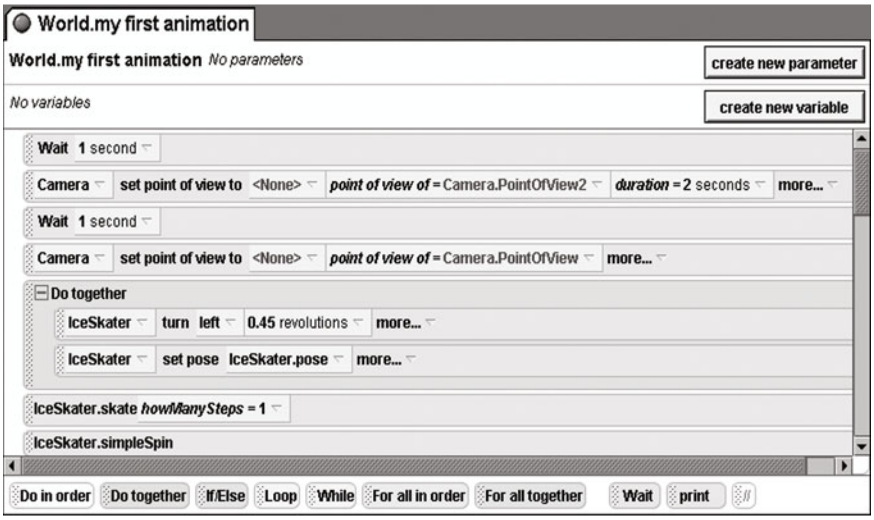

Figure 1. Programming code used to make an ice skater move in a 3D environment. Screen capture courtesy of www.alice.org. All rights reserved.

syntax errors, thus relieving much of the initial frustration. Secondly, Alice displays program sequences as animations so users can see their mistakes and more readily fix them. For example, if a character moves through a virtual world along the student's instructions but turns left instead of right at the end of the sequence, then the student can quickly pinpoint the problem. This leads to the development of good problem-solving skills (Kelleher & Pausch, 2006).

The pedagogy is that students "construct" or create the code necessary to make the animated figures function as they desire. Students can go through a basic tutorial to understand the screen and coding elements and are then given the opportunity to create their own animated sequence. As the students construct their sequences, they are able to see if they are getting the desired outcome by playing the animation to see if it functions as expected.

While students are constructing their code, the Alice software is teaching them basic programming concepts such as variables, if/then/else loops and parameters. Students learn about programming by creating short animation sequences. Students who gain more skills in using Alice can even create mini-video games that their fellow students can play and evaluate how much fun the interactions are. This is a strong incentive for many students and fully engages them within the learning process.

The goal of the Alice program is to combine the student's interests in video games with instruction in programming. Using this approach, students can see video game-like animations as a direct result of their manipulating object-oriented code. They learn technical concepts related to software development while having fun creating their own animations.

Simulation Software

A software simulation is the use of a computer environment to simulate objects or phenomena based on actual physical principles and constraints (Alessi & Trollip, 1985). In the ETE environment, software simulations can be used to create engineering projects not possible within a classroom. This might include building a roadway, designing an oil rig or designing and building a bridge to withstand the forces of a moving vehicle. Software developed at West Point to create a bridge provides an excellent example of using a software simulation in an ETE curriculum.

West Point Bridge Design – This is a constructivist-based engineering game designed to teach engineering concepts and skills related to the concept of building a bridge. The software was created by the US Military Academy, West Point, which sponsors the West Point Bridge Design Contest on the web (About the Contest, 2010.) The website contains software for creating a bridge crossing over a canyon. Students can create the bridge and then test it by driving a truck over the bridge. The software is also at the heart of the bridge design contest to encourage competition and engagement in an engineering task. The contest provides middle school and high school students with a realistic, engaging introduction to engineering.

In the contest, students download custom software and, using the software, design a virtual bridge to cross over a canyon. The contest has specific rules to guide the construction: the bridge must have no more than 120 structural members and no more than 50 joints, must pass a load test with no member failures, and no structural members may be drawn directly on top of one another. An example of a successful design is shown in Figure 2.

Figure 2. Successful bridge crossing. This image shows a student-designed bridge that crossed over the canyon successfully. Screen capture courtesy of http://bridgecontest.usma.edu/. All rights reserved.

The goal of the contest is to enable the students to learn about:

- Engineering through a realistic, hands-on problem-solving experience
- The engineering design process—the application of math, science and technology to create devices and systems that meet human needs
- Truss bridges and how they work
- How engineers use the computer as a problem-solving tool

The objective is to encourage students to think about the different variables and structures involved in creating a load-bearing bridge. The students receive instant feedback on the success of their design because the truck either makes it across the bridge or crashes into the river below. Again, the students are asked to conduct problem-solving processes, construct their own knowledge and build on past knowledge and skills to be successful.

Video Games

Another approach to engaging the third millennial generation is to create a video game environment in which students compete against themselves and others to accomplish specific goals, as described in Chapter 14 by Hacker and Kiggens. If well designed, these goals can be educational and beneficial to the students. Several projects have been undertaken to provide an educational, fun environment in which kids learn as they compete within a video game framework.

Several attributes of video games are useful for application in learning, including contextual bridging (i.e., closing the gap between what is learned in engineering or technology theory and its use): they provide high time-on-task and provide learners with cues, hints and partial solutions to keep them progressing through the subject matter (Federation of American Scientists, 2006) of engineering and technology. Below are two examples of applying video games to teach ETE.

Survival Master – The Survival Master game is a joint project of Hofstra University, Bloomsburg University and the CUNY Graduate Center sponsored by the National Science Foundation [http://gaming2learn.org/], described in depth in Chapter 14 by Hacker and Kiggens. The instructional and educational goals of the game are detailed more completely in Chapter 14 and provide a full description of the underpinnings of the game. This description will focus on the story created to support the educational goals of the game.

As indicated in Chapter 14, the project seeks to teach students engineering and technology skills through a video game designed for use in the classroom by teachers, covering topics related to engineering and math. The game involves teaching students concepts such as volume, heat flow, R-value and other information in the context of a video game where the learners must solve a series of obstacles or problems as they work to become a "survival master." The game teaches a variety of science, technology, engineering and math concepts while being fun and engaging for middle school students.

The instruction is designed to engage the student in an instructional process and in a story in a similar manner to many commercially available video games. Images from the game are shown in Figures 3–5.

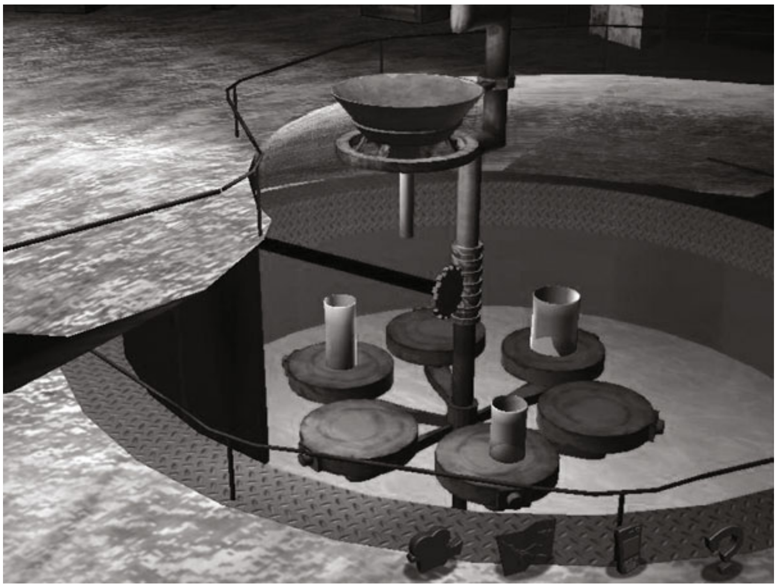

Figure 3. Inside the "Cave of Volume." Here students must calculate the volume of a shape and find the matching cylinder. Screen capture courtesy of "Survival Master." All rights reserved.

Figure 4. Inside the Labyrinth of Heat. This screen shows the player's viewpoint of an obstacle in the "Survival Master" educational video game. Screen capture courtesy of "Survival Master." All rights reserved.

Within the game, each subject or skill is performed in the context of the students training to become a “survival master” so they can teach others how to survive in a hostile environment. Students earn points for their accomplishments and unlock items such as power bars to boost their energy level throughout the game. The activities at each level contain common elements of commercially available video games, including unlocking chests having hidden surprises, shooting snowballs at targets and jumping from one platform to another.

Unbeknownst to the students playing the game, each level in the individual levels of the games prepares them for a group challenge to which they must apply the knowledge and skills learned individually into a group project. The second part of video game is a multiplayer game: the student must work in a group of four to build a shelter that will withstand extreme temperatures, a wind storm and snow load. The concept is that the skills learned by students playing individually in the first part of the game will be applied to the multiplayer game with the students working together to weigh trade-offs and develop reasonable compromises involved in building the shelter. Figure 5 shows a player orienting himself to the windswept wilderness.

As described in Chapter 14, the goal is to teach basic concepts related to engineering a structure while helping students think like engineers by considering trade-offs in terms of material usage, structure shape, structural integrity and cost

Figure 5. In the Wilderness. This screen capture shows a player navigating around the frozen wilderness during one of the Knowledge and Skill Builder activities related to heat loss. Screen capture courtesy of “Survival Master.” All rights reserved.

considerations regarding energy used by the players. The individual portion of the game ensures that all students have the basic skills needed to understand the broader engineering problem of building a shelter. The group portion of the game forces students to work together and think through the trade-offs involved in developing a shelter to withstand cold temperatures and wind and snow loads with each other and to create the right solution. The game has high-quality graphics, an interesting storyline and activities similar to commercially available video games. The goal is to combine the third millennial natural affinity for video games with educational content that teaches basic skills and knowledge, as well as more universal skills such as problem-solving and teamwork. The combination of entertainment and education leverages the cultural influences of the third millennial generation while providing a solid educational experience that will translate into the field of engineering.

Design a Cell Phone – Another game designed to focus students on the trade-offs and process of engineering a new product is simply called “Design a Cell Phone,” created and made available at www.edheads.org. This educational game focuses on an engineering design project that requires the learner to design a cell phone that would appeal to individuals over the age of 65. In the game, the job of the learner is to help an engineering director called Elena design and manufacture a cell phone to help senior citizens get the most out of new technologies. The learner gets a chance to review research data, make design decisions, test the design for effectiveness and ultimately observe the results of his/her design decisions. Figure 6 shows the screen in

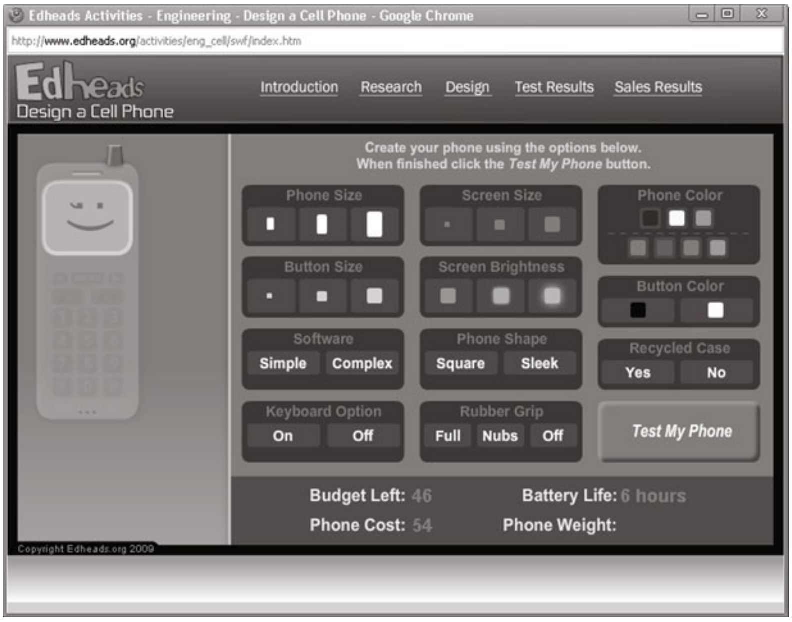

Figure 6. Design a Cell Phone. The design screen for engineering the features of the phone. Screen capture courtesy of www.edheads.org. All rights reserved.

which the player makes decisions about the phone design. Throughout the process, the game explains how engineers are required to make design and cost-benefit trade-offs, as well as the need to consider the target audience for whom the cell phone is being developed.

The pedagogy behind this game is constructivist-based. Students are given information in the form of "research" and during the process draw their own conclusions regarding the best design. The students are required to research the specifications of the new cell phone by conducting interviews, reviewing charts and graphs related to items such as desired battery life, button size and weight. Then they enter the design phase where they create a prototype by deciding on the size of the phone, the screen, the buttons and other key elements while trying to balance the cost of building the phone and the overall battery life.

Once a phone is designed, students test the results with a focus group of elderly individuals who provide feedback on what they like or do not like about the phone the student has designed, as shown in Figure 7.

Once the student has decided on the right engineering cell phone design, the phone is manufactured and the sales results are tallied. If the design meets the specifications and correctly balances the factors of cost, battery life, size and appeal to the target market, it will be a success. If the balance was not done correctly, the desired sales numbers will not be achieved and the student will be asked to redesign the phone and try again as shown in Figure 8.

Figure 7. Design Focus Group. A player can click on a member of the test group to obtain feedback about their cell phone design. Screen capture courtesy of www.edheads.org. All rights reserved.

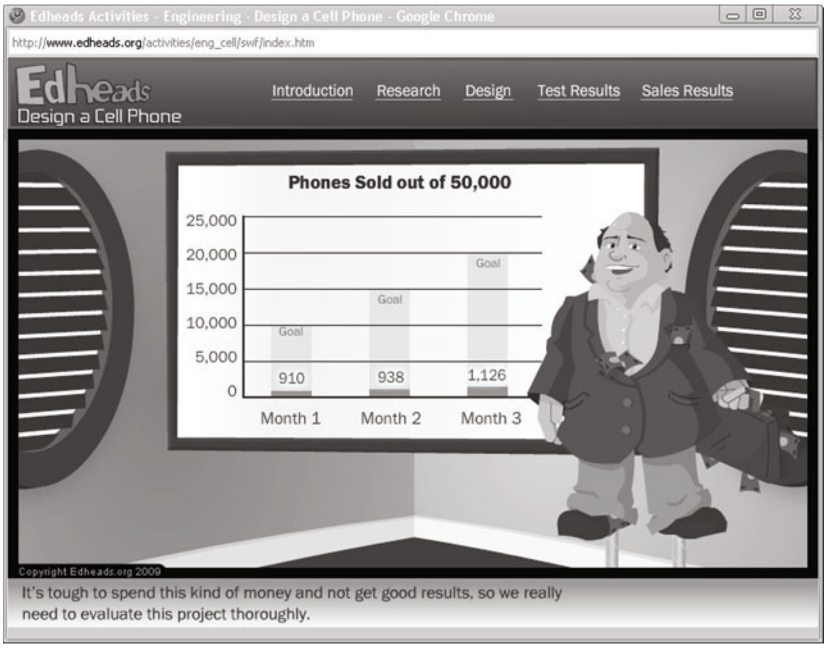

Figure 8. At the end of the activity, the learner is given feedback about sales numbers to determine if the phone was a success or a failure. Screen capture courtesy of www.edheads.org. All rights reserved.

Social Media

In addition to using video game technology to teach ETE topics, another technology that educators are just now beginning to leverage is social media. In fact, one of the most common topics of conversation on the social networks sites among middle school kids is education and schoolwork. Almost 60% of students using a social networking site talk about education topics and 50% talk specifically about schoolwork (Creating and Connecting, 2007). Social media is an umbrella term that refers to the ability of individuals to easily create and post information on the Internet in a manner in which others can view the materials and make comments on what was posted. Social media is about creating and sharing content online. The ease at which information can be uploaded to the Internet makes it attractive to students to create content and make it an effective instructional tool. "Central to the concept of Web 2.0 is that it involves connections and collaborations between people, and connections between ideas and hypermedia" (Finger & Jamieson-Proctor, 2009).

This section discusses two of the more popular social media categories. One is social networking as represented by the website known as Facebook and the other is the phenomenon of posting and sharing videos on the web through a video sharing site called YouTube.

According to Bozarth (2010, p. 55), “Facebook promotes conversation and can help to reduce the space and power issues between instructor and learners; it helps to ‘level’ the relationships and can support inter-learner interaction rather than just back-and-forth learner-instructor discourse often seen in traditional instruction.” It is an easy-to-use website where each person can create their own profile and post text, video and pictures and then connect with others through the process of “friending” them.

YouTube is a software platform designed for storing and distributing videos. The videos are limited in length, and the free service allows individuals or organizations to establish a channel whereby all of your videos can be stored in one place. Visitors to the site can rank videos, make comments and even link to the videos from their own websites.

The social media represented by Facebook and YouTube can have the following three primary functions in the area of ETE education:

– Extending communication outside the classroom
– Encouraging design collaboration
– Creating an e-portfolio of student achievements, activities and work in the engineering and technology field

Social Media as a Communication Tool Beyond the Classroom

One of the first uses of social media in the ETE curriculum is to extend discussion and communications beyond the classroom. Social media allows students, instructors and industry to connect outside the four walls of the traditional classroom and to carry out discussions related to ETE, as shown in Figure 9.

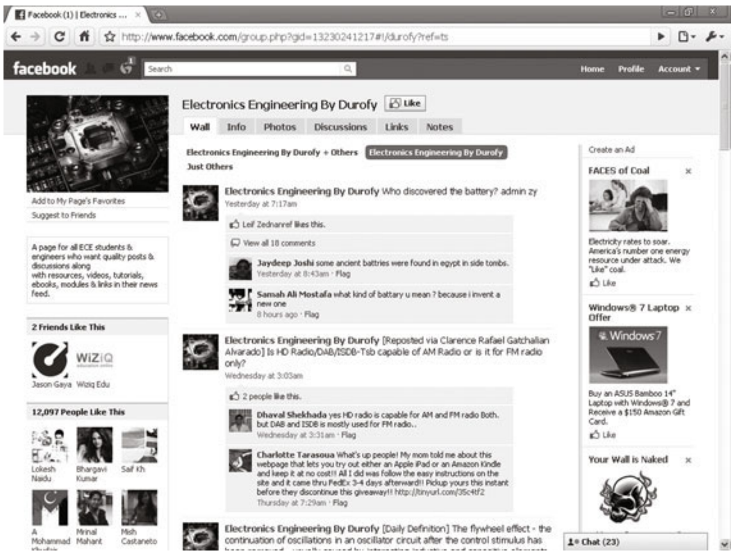

Figure 9. Facebook page. This page is used to post and react to engineering information.

One way to use Facebook is for an instructor to post comments and relevant information on a site set up to support his/her classroom's instructional activities, then encourage students to add their own comments on postings, add links and/or videos to the related information and post photographs. A Facebook site established around a class can be a central online site for sharing information with students and for students to share information with each other. It creates a conversation about ETE outside the typical constraints of a classroom. It provides the opportunity to extend the educational conversation. Its value is that it builds a community around the central theme of the class. Questions can be asked and answered, connections are made between people, and knowledge and ideas are exchanged freely. This taps into the third millennial use of Facebook technology and leverages the connectivity of the Internet.

The Web as a Source of ETE Video Content

Another example of using social media as a tool for learning is YouTube and its sister site TeacherTube. Both of these websites are video-sharing websites that literally contain hundreds of thousands of videos. The only difference is that TeacherTube is moderated to ensure that "school friendly" videos are posted while YouTube is more open in terms of the content it allows. On both sites, you can find video topics such as IBM experts discussing technology, virtual factory tours and even lessons on pneumatics. Both YouTube and TeacherTube provide interviews with experts, examples of engineering-related experiments and access to content only previously available in the classroom. The sites even contain videos created by students to show off their projects and work accomplished.

If you search YouTube for the term "engineering and technology education," you will find many examples of valuable educational information. One such example is shown in shown in Figure 10. You can also search for more specific terms such as "pneumatics," "manufacturing" or "CAD." Virtually any topic related to engineering and technology education can be found with the right amount of searching.

The idea behind using YouTube and TeacherTube is that ETE students can watch short videos in class, at home on the Internet or via their smartphones. YouTube allows for comments on the videos and creates a community around the content contained within the videos by allowing comments to be added. Additionally, the videos can be embedded on other websites and social networking sites such as Facebook.

The goal of leveraging existing videos found on the Internet is to provide access to content whenever the students have web connectivity. In the past, DVDs and VHS videos meant that when one person was viewing the content, a person across town or in another room was not able to access the content, but with web-based video content, multiple students in different locations can view the content simultaneously. Videos available on the Internet complete with social networking capabilities foster a network whereby students, faculty, alumni and industry professionals can share videos, comment on the content and exchange information in a networked environment regardless of their physical location.

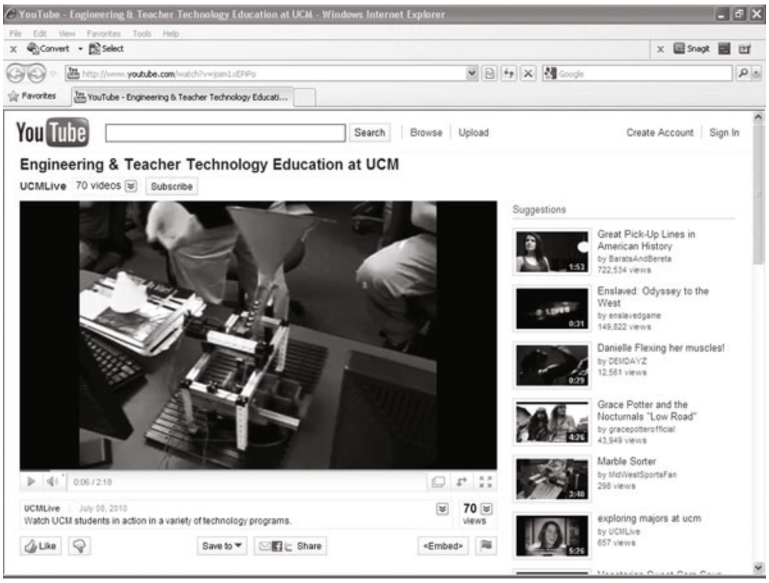

Figure 10. YouTube as a Resource. The page on YouTube, shows one of the many engineering and technology education-related videos available.

Encouraging Design Collaboration

While using social media as a tool to extend the classroom is a good first start with social media, many more opportunities exist to leverage social media within the ETE curriculum.

One innovative way of using Facebook is to post discussion questions that ETE students can answer focused around a design topic. The advantage is that students will have conversations with other students about their answers; Facebook provides students with the opportunity to post pictures or even videos related to answering the question. In answering a question, ETE students should be required to construct an argument, offering evidence and supporting resources, and apply sound design and logic principles for answering the question and creating a dialogue. The questions could include something like:

- Can you describe how a common household item was designed and manufactured?
- How can engineering and technology solutions solve the world's growing "clean water" problem?

As the students are answering the questions, the teacher can require them to post links to resources relevant to the topic, take a photograph of the item they are describing, and even post a video showing the item and discussing the design principles beyond its creation or behind the student's solution.

This approach could also be used in YouTube. Some ETE instructors have begun to ask students to record their meetings and thoughts around a design process undertaken when creating items such as a solar-powered car or a miniature wind turbine.

The students must not only design and build these items, but they must also record the process. This encourages the students to think about how they are designing and about the processes and procedures involved in their own thinking. In educational terms, this is called metacognition.

Metacognition is the state of being aware of one's own thinking (Marzano et al., 1988) and is a fundamental tool enabling learners to control their thinking. It has been revealed as an important skill in the fields of engineering (Case, Gunstone, & Lewis, 2001) and technology (Phelps, Ellis, & Hase, 2002). Rarely do students become self-aware of metacognition; instead, an instructor must point it out to the students as an important element in problem solving. By encouraging students to describe and narrate their project, an instructor can then review the video with the students, make comments about what they were thinking and observe how they approached the problem. This is one way in which third millennial technologies can be leveraged to increase the effectiveness of ETE curricula. It allows students to "watch" their own thought processes by requiring them to record and post the design project online.

Students can be asked to interview experts in the field and post the results on YouTube, providing them with the opportunity to meet individuals from the field and share these experiences with fellow classmates in a robust manner as opposed to a simple verbal or oral report. The videos can also show the products designed and built by the individuals being interviewed.

Creating an e-portfolio

Perhaps one of the most enticing aspects of social media is the opportunity for students to create a permanent and continually updated e-portfolio of projects, design thinking and online artifacts. e-portfolios are a way for learners to portray a story of their understanding of content at a deep level using a variety of media (Heinrich, Bhattacharya, & Rayudu, 2007). e-portfolios are a way for the concept of life-long learning to be incorporated into an ETE curriculum (Heinrich, Bhattacharya, & Rayudu, 2007).

In the early days of multimedia technology, e-portfolios required some knowledge of web development and an individual server on which a website could be housed. This was costly to maintain and usually the student portfolio disappeared or was placed onto a portable media when the student graduated. Today, with social networking tools like Facebook, educators and students can take advantage of free web resources that allow the portfolio to exist online indefinitely on the servers of the hosting software platform.

Using a social networking platform like Facebook, students can post information in a variety of formats and can augment the Facebook page by using other social media tools like YouTube for create videos.

The general characteristics of a portfolio as described by Meeus, Questier, & Derksare (2006) are:

– Student-centered
– Competence-oriented

– Cyclical with regard to action and reflection
– Multimedia-oriented

Online social networking tools leverage all of these characteristics to provide a permanent record of a student's accomplishment within the ETE curriculum.

Capitalizing on the affinity for social networking, an e-portfolio is networked, allows for feedback from the community, is constructivist in approach and allows for open standards. Tools like Facebook make it easy to update an e-portfolio and provide students with a low entry barrier (Heinrich, Bhattacharya, & Rayudu, 2007).

The accessibility of an e-portfolio created in Facebook or similar software provides the opportunity for peer-to-peer feedback, industry review of content and a level of professionalism by the students since they understand that their work will be viewed by someone other than just their teacher.

Incorporating e-portfolios using social networks into the ETE curriculum provides a linkage between third millennial technology and the content presented in class. It provides the tools for students to connect with others and to construct their own knowledge based on their interaction with the content online.

Smartphones

Taking advantage of the ubiquitous nature of smartphones extends the ETE classroom as students leverage the devices to assist them in learning.

As a platform, a smartphone provides easy access to applications required within the ETE curriculum. The most obvious use of a smartphone is as a scientific calculator. There are literally dozens of applications that can be downloaded that provide various versions of calculators, not to mention the fact that the hardware of many cell phones already have a built-in calculator that can perform some sophisticated calculations.

Already in the field, applications are being designed to provide formulas related to mechanical, electrical, chemical and civil engineering. Information is available for diverse topics such as brakes, elevators, metalworking, fluid viscosity, power demand, wiring, voltage drop, and many more.

As an example, one application used in the field determines the cost of a steam leak within a pipe. The application allows a person to approximate the cost of a leak and the potential savings involved by repairing the leak in a set number of days. On the calculator, you enter the steam pressure, the orifice/leak size and the cost of steam. The application then determines the steam loss rate and the cost of the leak per hour.

Figure 11 presents an example of an application showing geometric formulas. ETE curricula can include the use of such applications to familiarize students with the use of mobile applications to assist them in making calculations and using formulas just as professionals do in the field.

Smartphones also provide connections to instructors and other students. A student can use a smartphone to view teacher-created videos, text-message a request for help to a classmate or link to an important website online. Smartphones are another way of accessing social networking sites like Facebook and online videos through YouTube. Students can also use them to take photographs of design projects, post messages to a social network site about a design project and email information to an instructor.

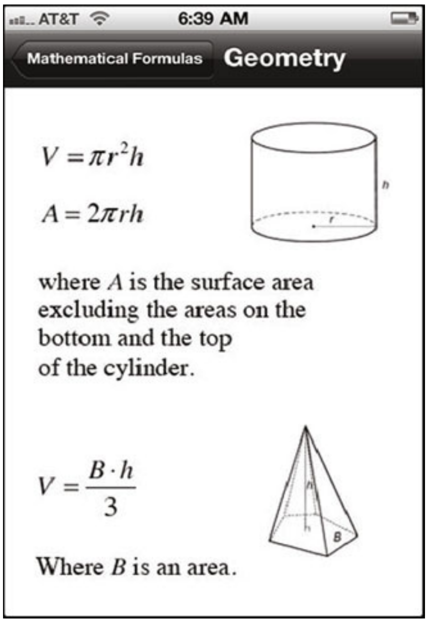

Figure 11. Formulas found in an ETE application designed for a smartphone.

Incorporating smartphones into the ETE curriculum extends the classroom and utilizes third millennial technologies to keep students interested and engaged in ETE subjects. A combination of using smartphones and a problem-based learning approach can foster facilitation, encourage students to talk with and teach each other, and create relevance for students by creating assignments that help them see the subject matter in the world around them outside of the classroom (Project Tomorrow, 2010).

CONCLUSIONS

It is clear from the examples above that third millennial technologies can be combined with sound pedagogy to create engaging and interactive learning experiences. As educators, we are obliged to examine the culture of the third millennium and compare it to our teaching methods and approaches in the classroom, and see if we can integrate elements into the ETE curriculum. This is especially urgent in the fields of engineering and technology because we are preparing students for fields in which technological acumen and a deep understanding of technological conventions is required for success. Engineers and technologists simply can’t function without technology. Given this reality, one of the most effective ways of integrating technology intelligently into the ETE curriculum is to leverage the ability of third millennial technology tools to allow learners to construct their own knowledge.

The ease at which students can create knowledge, view the thoughts of others and apply learning within a simulation or game must be recognized. Tools are now available to allow students to literally construct knowledge in the form of digital assets that could not be done a mere decade ago. Curricula must be re-engineered to have students participate in the following manner through technology:

– Creating an online dialogue about design or manufacturing complete with images, videos and links to support or refute conclusions
– Working through an engineering challenge presented in the form of an educational video game
– Looking up formulas while on a field trip to solve an engineering dilemma presented by the instructor on a mobile device
– Teaching students to create their own video game using specially designed software
– Creating a life-long passion for engineering and technology topics by constructing an e-portfolio that shows the maturation of a student's thinking over time

These are just some of the ways the ETE curriculum can begin to be shaped by allowing third millennial communication technologies into the classroom. But this type of integration will not be without obstacles. As with any sweeping change within a discipline, there will be cries that traditional methodologies are "proven" to be sound and should not be changed, and that those new technologies are a distraction from "real" learning.

The truth is that smartphones, social networking software and simulation software are the business tools of today's engineers, technologists and technicians (Kapp, 2007). These tools have already worked their way into the practice of the discipline as "serious" tools. The field uses these tools and innovative companies are gaining a competitive advantage with these communication technologies. This same type of innovation must be applied to the creation and delivery of the ETE curriculum.

By relating to the third millennial culture and incorporating items from this culture into classroom settings, we can provide a bridge between the digitally connected world of the students and the current ETE paradigm. The next step in the evolution of the ETE educational system requires a convergence of constructivist-guided pedagogy with the advanced, third millennial communication technologies to teach them the design, thinking and problem-solving skills required for success.

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REFERENCES

About the Contest. (2010). *West point bridge design contest web site*. Retrieved September 19, 2010, from http://bridgecontest.usma.edu/

Alessi, S. M., & Trollip, S. R. (1985). *Computer-based instruction: Methods and development*. Englewood Cliffs, NJ: Pentice-Hall, Inc.

Ayoreo. (2009). *Survival: The movement for tribal people*. Retrieved August 10, 2010, from http://www.survivalinternational.org/tribes/ayoreo

Beaumont, C. (2009). Half the world's population owns a mobile phone, *UN study reveal. Telegraph.co.uk*. Retrieved August 10, 2010, from http://www.telegraph.co.uk/technology/news/4933263/half-of-worlds-population-owns-a-mobile-phone-un-study-reveals.html

Blizzard Entertainment Press Releases. (2008). *World of Warcraft surpasses 11 million subscribers worldwide*. Retrieved August 10, 2010, from http://us.blizzard.com/en-us/company/press/pressreleases.html?081028

Borko, H., & Putnam, R. (1996). Learning to teach. In R. Calfee & D. Berliner (Eds.), *Handbook of educational psychology* (pp. 673–725). New York: Macmillan.

Bozarth, J. (2010). *Social media for trainers: Techniques for enhancing and extending learning*. New York: Pfeiffer.

Case, J., Funstone, R., & Lewis, R. (2001). Students' metacognitive development in an innovative second year chemical engineering course. *Research in Science Education*, *31*(3), 313–335.

Creating and Connecting: Research and guidelines on online on social and educational networking. (2007). *National School Board Association*. Retrieved on September 19, 2010, from http://nsba.org/site/docs/41400/41340.pdf

Delpit, L. (1995). *Other people's children: Cultural conflict in the classroom*. New York: The New Press.

Facebook Press Room. (2010). *Statistics*. Retrieved August 10, 2010, from http://www.facebook.com/press/info.php?statistics#!/press/info.php?statistics

Federation of American Scientists. (2006). *Summit on educational games*. Retrieved August 29, 2010, from http://www.fas.org/gamesummit/Resources/Summit%20on%20Educational%20Games.pdf

Finger, G., & Jamieson-Proctor, R. (2009). Assessment issues and new technologies: ePortfolio Possibilities. In C. M. Wyatt-Smith & J. J. Cummings (Ed.), *Educational assessment in the 21 century: Connecting theory and practice*. (pp. 127–146). London: Springer.

Gay, G. (2000). *Culturally responsive teaching: Theory, research and practice*. New York: Teachers College Press.

Grossman, L. (2006). Person of the year. *Time Magazine*. Retrieved August 10, 2010, from http://www.time.com/time/magazine/article/0,9171,1569514,00.html

GSM Association and the Mobile Society Research Institute within NTT DOCOMO. (2009). *Children's use of mobile phones: An international comparison*. London: GSM Association. Retrieved August 10, 2010, from http://www.gsmworld.com/documents/Final_report.pdf

Heinrich, E., Bhattacharya, M., & Rayudu, R. (2007). Preparation for lifelong learning using ePortfolios. *European Journal of Engineering Education*, *32*(6), 653–663.

Industry Facts. (2010). *Entertainment Software Association*. Retrieved September 18, 2010, from http://www.theesa.com/facts/index.asp

Kapp, K., & O'Driscoll, T. (2010). *Learning in 3D*. New York: Pfeiffer.

Kapp, K. (2007). *Gadgets, games and gizmos for learning: Tools and techniques for transferring know-how from boomers to gamers*. New York: Pfeiffer.

Kelleher, C., & Pausch, R. (2006). Lessons learned from designing a programming system to support middle school girls creating animated stories. *Visual Languages and Human-Centric Computing*, *IX*, 165–172.

Knowles, G. J. (1992). Models for understanding pre-service and beginning teachers' biographies: Illustrations from case studies. In I. F. Goodson (Ed.), *Studying teachers' lives* (pp. 99–152). New York: Teachers College Press.

Lawanto, O. (2010). Student's metacognition during an engineering design project. *Performance Improvement Quarterly*, *23*, 117–136.

Macgill, R. (2007). *Parents, teens and technology. Pew Internet & American life project*. Retrieved from http://pewresearch.org/pubs/621/parents-teens-and-technology

Marzano, R. J., Brandt, R. S., Hughes, C. S., Jones, B. F., Presseisen, B. Z., Rankin, S. C., et al. (1988). *Dimensions of thinking: A framework for curriculum and instruction*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Meeus, W., Questier, F., & Derks, T. (2006). Open source eportfolio: Development and implementation of an institution-wide electronic portfolio platform for students. *Educational Media International*, *43*(2), 133–145.

Nieto, S. (2004). *Affirming diversity: The sociopolitical context of multicultural education*. New York: Longman.

Phelps, R., Ellis, A., & Hase, S. (2002, December). *The role of metacognitive and reflective learning processes in developing capable computer users*. Paper presented at the 18th annual conference of the Australasian Society of Computers in Learning in Tertiary Education, Melbourne.

Project Tomorrow. (2010). *Students leverage the power of mobile devices through the Project K-Nect Mobile Learning Initiative in Onslow County*. Project Connect Evaluation Report. Retrieved August 29, 2010 from http://www.tomorrow.org/docs/Project_K-Nect_EvaluationReport_Final_Jul7.pdf

Reardon, M. (2008). *Americans text more than they talk: CNET News*. Retrieved August 10, 2010, from http://news.cnet.com/8301-1035_3-10048257-94.html

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. Grouws (Ed.), *Handbook of research in mathematics teaching and learning* (pp. 127–146). New York: MacMillan.

Villegas, A. M., & Lucas, T. (2002). *Educating culturally responsive teachers: A coherent approach*. New York: SUNY Press.

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