AC 2009-973: INTEGRATING HISTORICAL TECHNOLOGIES AND THEIR IMPACT ON SOCIETY INTO TODAY'S ENGINEERING CURRICULUM

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Integrating Historical Technologies and their Impact on Society into Today's Engineering Curriculum

Abstract

Technologies of all types surround us today. Most are now so commonplace that they are simply taken for granted. It is only when they do not work as expected that they are noticed. What is lacking is an understanding of how these technologies accomplish their tasks. People may know how to utilize many of these technologies but know nothing about how they really work. To many the social, political, and economic impact of technologies is also unknown. However, this may not be a new phenomenon. Humans have utilized technologies to enhance their capabilities since the beginning of time. It started with simple stone tools and progressed in steps over time to where we are today. Perhaps even early technologies were misunderstood by the people of the time and today's lack of understanding is just a continuance of that tendency. This may even be the case for today's engineering students. For the most part, current technologies are included in the engineering and engineering technology curriculum. However, technologies from the past are not. To remedy the situation, a project was initiated to enhance the engineering student's knowledge of how past technologies were developed. The objective was to improve their awareness of technology's historical heritage and foundation. In order to accomplish this an active learning hands-on component was added to a traditional lecture based course studying the effects of technology on society. Technologies from the past were researched and manufactured utilizing historical skills, tools, and methods. The students examined the artifacts during the classroom discussion of the particular technologies, giving them a better understanding of the engineering challenges encountered and how they were overcome. Initial results from the project indicate improved interest, awareness, and retention of the evolution of technology. Overall, the engineering students have an enhanced understanding of past technological issues that can be utilized to tackle future technological challenges.

Introduction

Technologies envelop our lives today. In fact, people have become so dependent upon them that they cannot comprehend living without them. Yet few people understand where they came from and how they work. Even more people are unaware of the social, political, and economic impact of these technologies on civilizations ranging from the distant past to the present. This may not be a new trend but rather a continuance of a very old one.

Technologies have been used since the beginning of time to augment human capabilities. It started with tools made of stone, wood, and animal parts that could be utilized for hunting, security, building, and other uses. Over time, a base of knowledge was established that evolved into much more. Inventions and innovations of all types were being created that allowed humans to modify and alter their environment. Some made life easier and more comfortable, while others extended human capabilities and increased productivity.

Today modern innovative technologies are routinely studied as part of the college curriculum in a wide variety of majors. This is especially true in the engineering fields. Students' learn how to utilize modern tools, machines, and devices to design, develop, and manufacture an assortment of new products. However, little time is devoted to studying technologies from the past to understand their importance and significance to society.

A new course was developed a few years ago to expose students to technologies from the past and fill this void. This junior level Technology in World Civilization course (Loendorf[7], 2004) was designed to broaden the students perspective of past technologies and how they were discovered and used. The main objectives of the course were to: (a) promote awareness of technological development, and (b) provide a rudimentary understanding of the social, political, economic, and cultural impact.

The course content explores innovations and inventions associated with ancient as well as retro technologies in the fields of agriculture, weapons, time measurement, industrialization, transportation, communication, and the environment (Loendorf[7], 2004). These encompass every aspect of engineering and engineering technology including mechanical, electrical, industrial, civil, and environmental. By understanding the development, use, impact, and consequences of past technologies, students are better equipped to tackle the challenging problems the future will bring.

Initially, the course was lecture and discussion based with a few videos included for variety. This format proved successful and the popularity of the course grew. Soon students from all disciplines across campus started enrolling in the course and it became apparent that the scope and method of delivery had to be enhanced to suit this diverse audience. The focus of the course would stay the same with a new added emphasis on technological literacy using a hands-on approach.

Theoretical or Conceptual Support

An unacknowledged paradox exists in our modern technological society. "As technology has become increasingly important in our lives, it has receded from view. Americans are poorly equipped to recognize, ... ponder or address, the challenges technology poses or the problems it could solve. And the mismatch is growing" (Pearson & Young[10], 2002). As a result, many people are not "technologically literate" today.

Most people's connection to technology is through finished consumer goods. They have very limited practical connection to the actual technology. "They do not build the devices they use, tinker with them to improve their performance, or repair them when they break. Because of this lack of engagement, people today learn relatively little about technologies through direct experience" (Pearson & Young[10], 2002). Therefore, the focus has shifted and technological literacy depends on what they learn in the classroom and from the media.

Technological literacy has been defined in many ways. "Technological literacy requires the ability of an individual to code and encode technological messages.... It means being able to understand and use words and their meaning" (Waetjen[13], 1993). "Technological literacy can be thought of a comprising three interrelated dimensions that help describe the characteristics of a technologically literate person... (1) knowledge; (2) ways of thinking and acting; and (3) capabilities" (National Academy of Engineering[9], 2008). "Technological literacy is the ability to use, manage, assess, and understand technology" (International Technology Educational Association[6], 2007). All of these definitions point to the knowledge and understanding of technologies.

There are some common elements of technological literacy that include knowledge about individual technologies, the process of technology development, the historical and cultural aspects of technology, and adaptability based on creative thinking. This requires four competencies: "(a) accommodate and cope with rapid and continuous technological change, (b) generate creative and innovative solutions for technological problems, (c) act through technological knowledge both effectively and efficiently, and (d) assess technology and its involvement with the human lifeworld judiciously" (Wonacott[16], 2001). It was with these objectives in mind that this project was conceived and driven.

One way to increase the practical connection to technologies is through a hands-on approach that implements some aspects of active learning. Similar techniques are learning by doing, interactive learning, and experiential learning. Active learning has been defined as “anything that involves students in doing things and thinking about the things they are doing” (Bonwell & Eison[2], 1991, p. 2). It is characterized by involvement rather than just listening, development of skills, higher order thinking, engagement in activities, and exploration of their attitudes (Bonwell & Eison[2], 1991).

Active learning engages and connects students with the subject they are studying (Crawford, Saul, Mathews, & Makinster[4], 2005). This can be accomplished through application, demonstration, interaction, or discussion as Allen[1] (2002) and Tileston[12] (2007) have stated. Active learning uses controlled exercises and interventions to provide opportunities for student interaction, involvement, and participation. These effects are often difficult to attain through traditional classroom activities. Bonwell and Eison[2] (1991), Sousa[11] (1995), and Weimer[14] (1991) have reported many positive learning outcomes resulting from using active learning techniques in the classroom.

Active learning transforms students into dynamic initiators of knowledge through participation rather than simply passive recipients of information taking notes. This occurs through a variety of classroom activities including interactive discussions, hands-on demonstrations, putting ideas and concepts into practice, and practical applications of the subject matter. This learning by doing approach requires participation, analysis, synthesis, evaluation, application, and reflection in terms of life, school, and work situations. When students take an active part in the educational process, they learn more (Davis[5], 1993).

Effective teaching focuses on the student while enhancing their learning experience. This allows them to attain and retain knowledge in memorable ways. Active learning requires a different instructional methodology, shifting the emphasis from professor-centered activities to student-centered activities. However, active learning requires more than simply organizing activities for student participation. Specific objectives or outcomes must be targeted to either illustrate fundamental aspects of the subject, or demonstrate vital processes. The challenge becomes presenting technical literacy topics in an active learning format that is interesting, motivating, and exhilarating.

Implementation

One of the most difficult aspects of teaching is presenting material in a fresh and appealing way. This is especially true for technical subjects. Now imagine an even more difficult hurdle, a course covering past technologies ranging from the ancient to the recently outdated. A historical perspective is offered featuring technologies that have greatly influenced and effected civilizations and societies since the beginning of time. A year and a half ago a project was initiated to enhance the practical connections or hands-on aspects of past technologies by adding some active learning components to these technical literacy lessons (Loendorf & Geyer[8], 2008).

The shift toward active learning in the classroom was implemented in several phases. Each of the phases required considerable preparation time by the professors for obtaining the raw materials and other resources required for recreating and collecting the artifacts. The impact on limited class time for hands-on activities versus lectures was also evaluated for each phase along with the potential risk that students would not participate or learn sufficient content from the next phase. This phased implementation approach allowed for assessment and examination of each phase independently prior to committing resources for enacting the next phase.

The first step was the modification of traditional lectures to include brief demonstrations of ancient technologies. This was coupled with an in-depth discussion of the technologies utilized. Students were shown exactly how ancient tools were created, sometimes by incorporating other ancient tools, along with how they were used. All of the materials used were described as well as how they were obtained or where they were found. Why one type of stone or wood was selected over another is also explained in detail.

The second phase included controlled exercises requiring student involvement and participation. Great caution had to be exercised at this point to assure student safety since most ancient tools, artifacts, and other items were extremely sharp and dangerous. All of the objects that would be handled by the students were deliberately dulled by rounding or blunting for their protection. Further instructions outlined additional precautions for handling the items. Then a hands-on intervention allowed each student to touch, handle, and feel how the implement functioned while performing its task. The use of the object was emphasized including how it fit into your hand or hands along with how it actually felt like it wanted to do its job. Students need to be exposed to, and made aware of, how a technology works before they can move on to actually recreating them.

The third phase, which is planned but not yet implemented, involves the actual student recreation of ancient and other historical artifacts. This would include making stone tools, different types of armor, compound bows along with arrows, pioneer objects, and a host of other artifacts from raw materials. This process could then be expanded to replicate technologies that are of a more recent nature over time. The challenge is how to fit these projects into a lecture based course. Without a laboratory segment for the course, each of these projects would have to be completed outside of class without the professor's supervision. This could lead to a liability issue. Work is continuing on how these projects could be implemented without risking the safety of the students.

Together these phases represent a movement to active learning. The intent is to break the barriers that accompany a strictly lecture based class and include a hands-on component. At this point, not all of the aspects of active learning have been incorporated into the course. However, many have been used to engage the students and aid in their learning process.

Creation and Collection of Historical Technologies

The project began by researching past devices that could be recreated using the same tools and methods originally used. Modern technology has a vast volume of documentation that accompanies its creation; ancient technology is short on its documentation. As a result, it is difficult to find an ancient book discussing the "then" current technology from 10 to 20 thousand years ago. However, Crabtree[3] (1972), and Whittaker[15] (1994) studied the history of the stone tool period and documented how to recreate many artifacts. Using this reference material, the process of building a collection of Stone Age tools shown in Figure 1 was accomplished.

Figure 1. Recreated Stone Age Tools.

The first step was the creation of a basic set of flintknapping tools. Then, using this tool set, the creation of the rest of the stone and bone items included in the Stone Age tool collection was completed. To help insure the safety of the students, all of the Stone Age tools were purposely dulled. This collection also includes: stone choppers, sinkers, digging stones, arrowheads, hand axe and axe head, animal hide pouch, bone awl, obsidian, and flint samples.

Some historical technologies still exist; the challenge was finding them at a reasonable cost. After considerable research, the process of building and accumulating a compilation of Pioneer Days technology began. This resulted in the collection that is partially displayed in Figure 2.

Figure 2. Pioneer Days Technology.

The barbed wire used in this project was bought from sources in Texas, while other items like the glass insulators, were purchased locally. All items required cleaning, with special attention given those made from metal – they were sandblasted and painted with a rust-inhibitor. This collection also includes: railroad spikes, animal traps, hay hook, scythe, plow shears, various sized horse shoes, other farm implements, cooking pots, meat grinder, oil skin slicker, boots with spurs, clothing specimens, oil lamps, and many other items.

Further expansion of the project has fostered additional collections of historical technological artifacts. The printed word led to the publication of pamphlets, newspapers, and books promoting literacy and spreading knowledge. This process developed from stone carvings, wood blocks, and evidentially moveable type. The printing collection includes stone carvings, carved wood blocks, copper engravings, moveable type, type tray, output from a Linotype machine, an offset press, and other relics.

The latest collection being assembled includes examples of armor and armor technology. Throughout the ages it has always been a back and forth clash between offensive weapons and defensive measures. When new weapons appeared on the battlefield, they created a need for protection. Soldiers began covering themselves with a variety of items to shield and guard them from harm. These objects became the first types of armor.

When covering the historical period of armor, two focal points where chosen. First, a sample from the Japanese leather period was selected, researched and re-produced. The chosen piece is referred to as Retainer's Armor (Figure 3). This armor would have been worn by a hired fighter and considered a step lower than a Samurai.

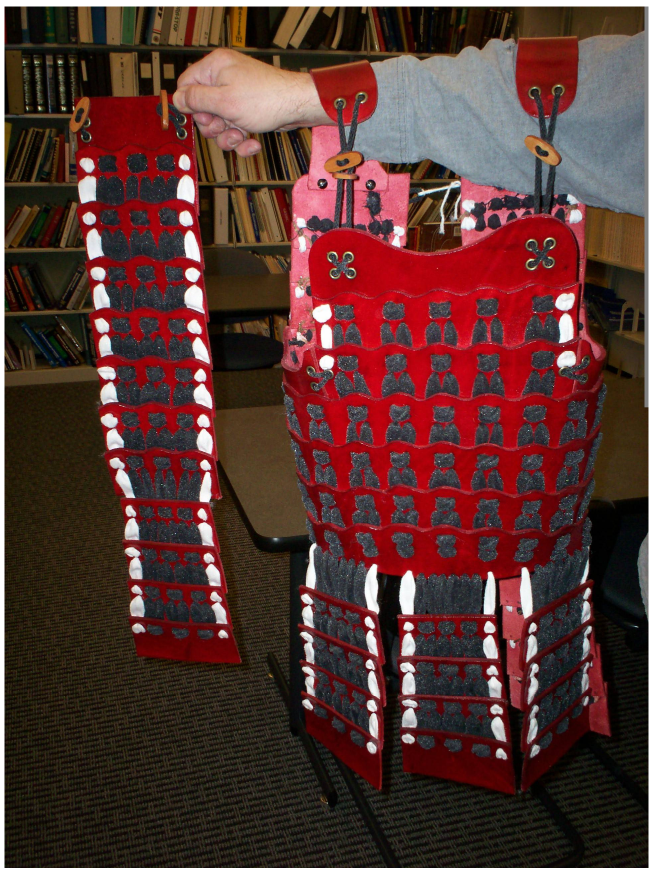

Figure 3. Japanese Armor.

Second, in contrast to the first choice, a few samples of chain mail were reproduced. One of the items, called a Chain Mail Coif (Figure 4) was worn as a head covering underneath a helmet. This style of chain mail would have been used in Western Europe. This particular artifact was recreated using aluminum links for ease of construction along with a lighter weight. However, it is a realistic and representative sample. Other pieces of chain mail armor have been constructed out of iron links. These are much heavier and are used for comparison purposes and contrasted with the aluminum for levels of protection. Additional items are currently being constructed and pursued for this collection.

Figure 4. Chain Mail Coif.

As the project continues, it is likely that new collections of historical technologies will emerge and be collected. The project has grown in popularity and taken on a life of its own. Word of the project promoting technological literacy has spread and many people have come forward volunteering to donate items for the collections. It is certain that some of the contributed items will lead to additional collections that expand further the ability to display, explain, and expose students to technologies from the past.

Educational Delivery Vehicle

To help with the classroom delivery of these newly created and collected technological items, two audio-visual (AV) carts were acquired, cleaned, and decorated. The term “Educational Delivery Vehicle” or “EDV” was coined to help convey the purpose of the AV carts. Since classrooms are scheduled centrally, a means to transport the artifacts to various classrooms was needed; no instructor is assigned a permanent lecture-room.

The cart containing the Stone Age tools (Figure 5) was painted in a camouflage pattern to distinguish it. The cart containing the Pioneer Days technology (Figure 6) had two weathered wooden posts attached to the cart and barbed wire attached to those posts, along with a turn of the century (1900s) meat grinder. The EDV also serves as an excellent display platform for the lectures and exhibitions. In fact, the height of the old AV carts is ideal for use in the front of the classroom allowing even the students sitting in the back of the room to observe everything that is occurring.

Figure 5. Educational Delivery Vehicle 1 (EDV 1).

Figure 6. Educational Delivery Vehicle 2 (EDV 2).

A third EDV is used to transport the printing collection and a fourth will be needed for the armor artifacts. It is expected that additional EDVs will be required to convey the exhibits to and from the classrooms as new collections develop. However, they have created an unanticipated consequence. Where can they be stored when not in use? This dilemma has yet to be resolved since storage space is always very limited.

Classroom Experience

Exposing students to examples of technologies from the past allowed them to better understand how they were built and used. All too often students are passive participants in the learning process just listening, observing, and taking notes. The ability to actually see, touch, and handle these artifacts peaked their admiration for the resourcefulness and creativeness of people long ago. A new dimension utilizing active learning was added to their educational experience increasing their technological literacy.

The students looked forward to demonstration days wondering what technologies would be presented and discussed. Their attention and interest level remained high for the entire class session. As devices were discussed in front of the class or passed around the room for them to examine their curiosity and inquisitiveness prompted many questions and comments. Even students that rarely participate in classroom discussions took part.

In the classroom, the students received these recreated tools and artifacts with curiosity, thought, and interest. The presentation, observation, and discussion of the Stone Age tools led to a dialogue filled with questions, insight, and thought. The success of this active teaching method led to the expansion of the project into other old technologies.

As the students exited the classroom at the end of the sessions, their conversations centered on the technologies demonstrated along with how they were made and used. They continued to talk about the technologies displayed for days after, bringing up new aspects, concepts, and ideas about them. Enrollment for the course increased as the students mentioned the demonstrations to their friends and recommended that they take the course as well. In addition, the students were always asking about what would be demonstrated next and when, much to our delight.

Lessons Learned

By using demonstrations and active learning principles to recreate old technologies and improve technological literacy, several lessons have been learned. Many of them have been incorporated into the materials, demonstrations, and hands-on experiences in order to augment and enhance the course. The result was a very interactive classroom experience with a heightened level of student involvement.

After the implementation of active learning techniques to the course material, the students were more enthusiastic and positive about the learning experience. They became engaged and involved in the learning process as active constituents rather than passive participants. This was even reflected in the positive course and faculty evaluations completed by the students after the end of the academic term.

The presentation and discussions of past technologies enhanced their level of technological literacy in many ways. They had a better understanding of the concepts, characteristics, and relationships between people and technologies. They had a grasp of the social, political, economic, and cultural aspects of technology. They had an appreciation for the problem solving process along with the research, design, and development required to introduce new technologies.

Conclusions, Reflections, and the Future

The projects objective of increasing the student's awareness of technological literacy was a success. Implementing the principles of active learning in the classroom really brought results. Instead of having the students travel to museums to see or look at pictures in books of these historical technological artifacts, the technology comes alive for them in the classroom. A passive learning environment has been transformed into an active learning environment.

This interactive format has excited and inspired the students as well as the faculty. The results indicate an increased student participation, awareness, interest, and retention of just how technology has evolved greatly enhancing their technological literacy. After completing the course, students have a good understanding of past technological issues and how the same techniques could be used to solve today's and tomorrow's problems. Looking back, the project was well worth the time and effort expended to put it all together and the objectives for the project were successfully met.

Plans for the future are also becoming clear. Additional exhibits containing many other types of displays will be recreated or collected to expand our current offerings. Some people have offered to donate items to the collections as well as objects for new ones. Others have volunteered to donate time or materials to build new items using the technologies from the past. One thing is certain; this hands-on laboratory approach to a traditional lecture based class works well and will be continued.

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