Annotated Bibliography

Engineering the Future: Designing the World of the 21st Century. (2007). Retrieved February 20, 2007, from the Boston Museum of Science's Web site: http://www.mos.org/etf/. Educators at the Boston Museum of Science have created technology curriculums for both elementary and high schools in response to Massachusetts's recent inclusion of technology in their educational frameworks. This curriculum, provided for high school teachers, involves students in a variety of technology related activities, giving them a broad exposure. In addition to a textbook, the museum created a teacher's guide and engineering notebook that functions as a workbook for students. As my work progresses, this project will mainly serve as a source of inspiration for my curriculum. While definite differences between teaching general technology and FIRST Robotics exist, I hope to include the best ideas from this project, especially the engineering notebook, in my curriculum.

Ewell, Peter. (1999, December). Organizing for Learning: A New Imperative. AAHE Bulletin, 3-6. Peter Ewell, from the National Center for Higher Education, uses this article to argue that complete institutional change is necessary for learning to be improved. In an attempt to end the ineffective application of piecemeal educational policies, this plea for change is directed towards college faculty and administrators. While neither I nor FIRST Robotics is a college, this article will inform my project by warning me of obstacles that may appear. Additionally, the article provides a list of basic facts about learning and how to promote learning that should be useful as I decide on the pedagogical techniques to use in my curriculum.

Massachusetts Science and Technology/Engineering Curriculum Framework. (2006). Retrieved February 20th, 2007, from the Massachusetts Department of Education Web site: http://www.doe.mass.edu/frameworks/scitech/1006.pdf. Massachusetts recently joined a short list of states that include a specific technology element in their statewide curriculum frameworks. This action contrasts other frameworks which rely on science to cover both science and engineering. This document was prepared by the Massachusetts Department of Education with input from teachers across the state. While some have resisted the idea of adding technical content to the curriculum, it makes perfect sense to me. This resource is useful to my project because it provides information about what technology-related concepts educators think are important for students to learn. Comparing these beliefs to my own will hopefully yield interesting conclusions about perspective and how to make technological education important to students. Additionally, FIRST Robotics provides an excellent opportunity to reinforce classroom concepts; knowing the educational framework allows me to link FIRST to the classroom.

Mazur, Eric. (1996). The Problem with Problems. Optics and Photonics News, 6, 59-60. Eric Mazur, a Harvard Professor and author of *Peer Instruction: A User's Manual*, briefly explores the function of a problem assignment in this article. He points out that most end-of-chapter problems require only identifying the required equation, knowing where the provided numbers belong, and then turning the crank. In his view, problems that require some level of estimation, guessing, creativity, and reasoning are far superior in teaching students both logic and confidence. Additionally, these open-ended questions better resemble real-world problems that students will face. FIRST is all about one big, open-ended, real-world problem that students have six weeks to solve, so understanding why this type of question results in better learning is

advantageous. This will also press me to include open-ended practice problems, possibly drawn from previous FIRST Robotics season, throughout my curriculum.

Polya, George. (1965). Mathematical Discovery: On Learning, Teaching, and Learning Teaching. 2, 99-106. In this article George Polya explains his view of the teaching process, focusing on the fact that no single, mechanical process will work in all situations. He points out that not only must lessons be customized for the students being taught, but also for the professor's style, provisions of the classroom, and so on. As a mathematician and author of three books on the subject of teaching problem solving skills, his opinions on this topic carry weight. His philosophy of learning requires involvement, motivation, and multiple phases of reinforcement on both the students' and teacher's part. My curriculum will hopefully incorporate these basic concepts, providing both student and teacher buy-in to the processes.

Wiggins, Grand, & Jay McTighe. (2005). *Understanding by Design*, 2nd edition. Association for Supervision and Curriculum Development. Wiggins and McTighe are well known for their backwards design approach to curriculum planning. Instead of starting with activities or material to cover, they suggest deciding on goals for students first. This idea seems reasonably trivial from my perspective as an engineer used to design, but my situation is very different from that of a teacher thrown into a classroom without time to plan. I am going to take advantage of the time I have to develop my FIRST Robotics curriculum and deliberately develop goals for students that result in useful, robot-creating abilities. This source mainly serves to help me develop my curriculum, but it also provides me with a good idea of the current state of education based on what changes are being called for.

Provisional Thesis Statement

In order for students involved in the FIRST Robotics program to perform well and receive the maximum possible benefit, they must be prepared before the build season and competition begin. Most of this preparation takes the form of learning, with required subjects ranging from physics to brainstorming to mechanical design to programming. Currently, no true curriculums are available for teachers, mentors, or team members interested in conveying these skills to students. However, applying pedagogical techniques to the specific material that teams require can result in an effective curriculum for future FIRST instructors. Obviously, doing this requires an understanding of both the FIRST program and educational techniques. Through reflection on previous experiences involving FIRST and research into current pedagogical practices, these conditions can be met.

FIRST and its benefits are important in our age as humanity relies more and more on technology for our survival and happiness. While we have had technology for thousands of years, the past hundred years have seen the pace of technology progression cross a threshold requiring more specialization and education than before. Nowadays, most jobs require computer skills, technical competence is almost a required life skill, and the need for technical professionals continues to increase. FIRST Robotics provides one avenue for encouraging students to engage in technical studies while providing them a useful and hands-on head start in the area. A good curriculum would increase the effectiveness of both of these actions, resulting in a society better able to push forward in the face of increasing complexity.

Disciplinary Analysis

As this project requires an understanding of not just education techniques, but also the FIRST Robotics program, this analysis will begin with an introduction to FIRST. A review of educational techniques will follow this overview.

FIRST's acronym expansion actually provides some information about its purpose: For Inspiration and Recognition of Science and Technology. Founded in 1992 by Dean Kamen and Woodie Flowers, FIRST seeks to excite students about careers in technical fields through the same type of exposure that they have to sports growing up. For example, the co-founders frequently point out that a much higher percent of children aspire to be professional baseball players than is possible. At the same time, very few children teeter around saying "I want to be an engineer when I grow up; they're so cool!" FIRST aims to make engineering cool, fun, and visible to students at an early age than they are otherwise exposed.

Originally only a high school competition between 28 teams, FIRST has expanded across America and internationally to over 1000 teams and 36 regional competitions. To reach out to younger groups, they have added the FIRST Lego League and FIRST Vex competitions, which are targeted at younger students and those seeking a simpler challenge. While this project focuses on the high school FIRST Robotics Competition (FRC), some of its output may be adaptable to the other programs.

The tasks a team's robot needs to complete are defined by that year's game, which may consist of activities such as picking up balls, throwing them through a ring, moving goals around the field, or lifting up other robots. Additionally, teams are formed into two or three member alliances, forcing cooperation in the midst of competition. Because the game and rules change, teams must build a new and different robot every year; ideas can be reused or adapted, but there is always new construction. In recent history, games have been played on a 24x48 feet field and robots are limited to a starting size of 28x38x60 inches.

Teams have to design, build, and test their robot in a six week period known as build season. The announcement of the game kicks off build season in early January, and shipping the robot off to a competition ends this, the most hectic period of a FIRST participant's life. While time commitments during build season vary, it's not uncommon for teams to meet for four hours every day after school and then come in on Saturdays to put in another eight hours. Competitions are held throughout March and consist of practice matches on Thursday, qualifying matches on Friday and Saturday, and final, elimination matches on Saturday.

The parts of the school year before build season and after the competitions are known as the preseason and postseason, respectively. The preseason is generally spent preparing for build season, through activities such as fundraising, organizing, recruitment, and educating new team members. Because teams use this time to teach robotics related skills to their members, it is of particular interest to this project; any FIRST curriculum would best be used here. Teams are generally less active in the postseason, but still do things like community outreach and robot demonstrations to sponsors. A few teams go even further and carry this outreach or engage in some other robotics related project over the summer.

Obviously, high school students would have a hard time building a robot by themselves, so they are supported by teachers, parents, and mentors. As they primarily provide technical assistance, mentors are frequently professionals from industry or college students with a technical major. Many of these students and a growing number of these professionals are alumni of FIRST. While technically competent, most mentors have no educational training, reducing their effectiveness. Hopefully, supplying these mentors with a pedagogically sound curriculum can help to solve this problem.

FIRST clearly has a culture of its own, and an understanding of that culture is critical to successfully creating or understanding anything meant to function within it.

In its early years, no thought was given to technical education. Methods were borrowed from teaching other subjects and as the world became increasingly complicated, they were hobbled together to form a kind Frankenstein pedagogy without ever looking back. Only now is a coordinated effort coming together to study technical educational and try to find better ways to approach it. For instance, schools are now trying to include more realities in their programs, such as teamwork and communication skills. Active student involvement in learning, such as project based learning is also gaining a foothold as a better way to do things. Olin serves not only as a center of study for the field, but also as prime evidence for its current surge.

One of the most widely know figureheads of technical education is Richard Feynman, who gained his popularity both for having something interesting to say and for saying it interesting way. In books like *Surely you're joking, Mr. Feynman!*, he discusses a number of failings of educational systems, both in America and abroad. At the same time, he relates stories from his own, unique education, showing that there is another way (as long as you're brilliant). Feynman's ideas and work are not only a good reference, but also a good connection to make to popular culture.

In terms of curriculum design, *Understanding by Design*, by Grand Wiggins and Jay McTighe, is the current focus of many educators. While engineers have been taught to decide on desired outcomes first and work back from there, apparently educators have not. Failing to decide on desired results has created many inefficient activities that students go through regularly. Fortunately, FIRST requires a specific set of abilities and gaining each of these abilities is an obvious goal for a FIRST curriculum.

For better or for worse, teachers know that education is an art, not a science. While this limits the universality of any principals in education, it's still possible to note and study general tactics that work better than others. This leads directly to the idea that any curriculum will require adaptation to the students, the teacher, and a variety of other surrounding factors. Beyond this slightly frustrating truth, a few principals are accepted in education. For instance, student involvement in the lesson, especially hands-on involvement, helps to maintain interest and spur learning. Also, students with a motivation for learning beyond wanting to get a good grade do better as they, predictably, put more effort into the lessons. Finally, it is accepted that students will not really understand a topic until they have visited it multiple times. This phenomena is frequently referred to as spiral learning, in reference to the idea that students spiral in toward understanding of a topic through multiple accounts.

As a field and a part of our society, education is conservative. Education is a big part of turning children into adults and there is a constant fear of making a mistake in this process and breaking a generation. This mentality is valid to an extent, but as the world changes more rapidly around us, education must change to keep up. Already, there is evidence that it is falling behind. For instance, many children now learn more about how to use a computer through a combination of experimentation and consulting their peers than any formal teaching in school.

As detailed in my proposal, this project is important because it will explore ways to increase the effectiveness of technical education. Doing so is the only way to catch up with the rapid changes that scientists and engineers continuously add to our world. Humanity has relied on technology for our survival and happiness for thousands of years, and our educational system seems to have worked well enough in those times. In the past hundred years, however, our pace of technology progression appears to have crossed a threshold requiring more specialization and education than before. Nowadays, most jobs require computer skills, technical competence is almost a required life skill, and the need for technical professionals continues to increase. At the same time, the teaching of these skills hasn’t been thoroughly studied and isn’t encouraged by our society. Only further research, reflection, and testing of technical education can address this problem.

When Thomas Edison said that invention requires more perspiration than inspiration, he didn’t limit his comment to inventing new devices. In fact, it applies to creating curriculums as well. While some time will be spent on research and reading, more effort will be invested in actually developing the curriculum and shaping into a clear, interesting, effective, and easy to adapt set of material.

From my conversations with my mentor, Professor Ken Hawes, these methods seem on target for current curriculum development. What will probably have the greatest effect on the output is the initial development of goals and the amount of time dedicated to creating and refining the curriculum. Educators are frequently too busy, resulting in a lack of time to fine tune curriculums both for general release and for a specific situation.

While education is not a hard science and no optimal solution exists, developing a flexible FIRST curriculum that can be adapted to different robotics teams is a possibility. Keeping in mind the importance of designing the curriculum to meet a team's needs while maintaining student involvement and motivation should result in a solution that can be used to prepare FIRST participants for build season, competitions, and life beyond high school.