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TEACHING TECHNOLOGICAL LITERACY K-12 "PREPARING FUTURE ENGINEERS & NURTURING A DEMOCRATIC SOCIETY" A CASE STUDY OF EXEMPLARY PRACTICE

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Introduction

Shelly and Melanie stood outside the school staring at a handheld GPS in one pair of hands, and their "tech notes sheet" in the other. It was a beautiful sunny afternoon in Hailey Idaho. I watched as they discussed how they had seen Mr. Thode, their teacher, set the way points in the GPS to aid navigation around the school for others to follow. Shelly and Melanie had tried hard during the brief demonstration to catch every little detail of the instructions in their notes, but were still struggling to figure out the different menus and icons displayed on the screen of the GPS they now hovered over. Discussion was intense back and forth as they hypothesized what each symbol meant and what they should do next. Before long, they ran back into the building seeking further instructions. Soon they returned. Not with the answer, but rather a suggestion of where to look in the menus. Before long they were on their way, running around the school yard, laughing, and writing in their notes – led by the GPS system.

These students like many 6th graders in schools across the United States are preparing to become contributing citizens in an increasingly technologically advanced society. Unlike most students however, these students had the opportunity to be working on their 16th technology activity of the tri-semester in a class dedicated to teaching technology. When asked what they were learning, one simply said, 'technology.' The other, stated 'I am learning how to be responsible and a good worker. Also, I am learning to use different machines.'

One may argue that our k-12 educational system has an essential stewardship in teaching children to become technologically literate. This literacy will help develop interest and future engineers in the United States of America. Sadly enough though, "the issue of technological literacy is virtually invisible on the national agenda" (National Academy of Engineering & National Research Council, 2002) and there are only an approximate 35,000 full-time technology teachers in the public school system (personal communication, K. Starkweather, ITEA President, April 5, 2001) that teach dedicated technology courses where students learn about the human-designed world with the associated systems, resources, and processes used and needed to design manufacture, operate, and repair these artifacts.

Research

Since we live in a society so heavily influenced by technology, it is imperative that we learn more about how to teach technological literacy. If we know how to better teach technological literacy, including what works and what doesn't, given specific goals, outcomes, resources, and situations, we can better prepare a technologically literate citizenry to ensure our democracy will continue to flourish. Recently a case study was conducted to investigate this challenge to understand the practice of an exemplary technology teacher (Mr. Brad Thode, the instructor of the Wood River Middle School Technology Education Program in Hailey ID), his vision of technological literacy and how he shapes classroom instruction to achieve that vision. Daily observations were conducted over a period of 4 weeks with the teacher and students. Interviews, video tape and document analysis, student samples, focus group, and a questionnaire were used as data sources. In analyzing the data and writing the final case study, it became quickly apparent that Brad Thode's nonlinear approach to teaching technology directly addressed multiple issues brought up in the *Technically Speaking: Why all Americans Need to Know More About Technology* document published by the National Academy of Engineering (NAE) and National Research Council (NRC) in 2002. The purpose of this paper is to introduce the case study and consider how Brad Thode's methods of teaching might address some of these issues.

The Case

Brad Thode is a veteran teacher who has been involved in teaching technology for over 30 years. He understands that teaching is not about instilling knowledge in young persons heads, but rather, allowing them to discover, experiment, and struggle to make connections to their experiences and their own lived reality.

> It is about opening wide all technology education exploration doors for students; not setting learning limits defined by curriculum organizers. It's about taking advantage of that teachable moment when a student hears about a new technology application and wants to try it right now. It's about never having to say 'that's a good idea, but we can't get to that until next semester.' It's about being a part of the decision making process In the class. By taking an active role in the class, students feel more enthusiastic and excited about the learning process. Technology Education as a subject, lends itself easily to this concepts. Few students are passive containers waiting to be thrilled by the vast knowledge of the teacher. The nonlinear approach to curriculum organization not only makes the curriculum come alive for the student, but keeps the teacher excited and enthused as well (Thode & Thode, 1997).

This constructivist approach is central to the amazing outcomes of his program. He calls his approach a "nonlinear" approach. According to Thode, nonlinear refers to students doing different projects at different times in the pursuit of knowledge and understanding.

> The idea is to capitalize on the teachable moment. If you stop and think about the way most people use the Internet, they start out looking for something -- maybe a vacation to Hawaii or what ever. They may end up learning about how nuclear physics works or something like that. It's nonlinear. You go one place then it leads someplace else, and then you're all over the place. I believe that's the way people learn best because they are interested in it and it's nonlinear. So you're surfing essentially. So by allowing the students the ability in school to surf the knowledge that's available, I think that's one cool way for them to learn.

In practice, the nonlinear technology curriculum is introduced one activity at a time based on the teacher's interests, student's interests, current technical innovations, resource availability, and students' past successes. (Table 1 shows a list of the curriculum used in the 6^{th} grade tech class for the semester I conducted my research.) The curriculum is dynamic and covers state and national standards but is based on student and teacher interest. This demands flexibility. From semester to semester a common core of activities have taken shape but out of the four years I have visited the school, I see differences in activities to allow for interest, adaptation, and improvement. There is more consistency in the 6th and 7th grade tech classes to provide more structure and a common curriculum, but by the time students get in 8th grade, they have the chance to work on real-world engineering projects they choose for an entire semester. During the case study, students were working on advanced engineering activities that included the design and prototyping of a two-person mars rover, a levitating/docking space station, and fiber optics manufacturing. Prior student engineering projects have included the design of a human wind tunnel, a human insect chair, flight simulator, and micro gravity moon walk simulator. With all of these projects, real- world engineers have been invited to work on the project team with the students as they solve their design challenge.

Table 1

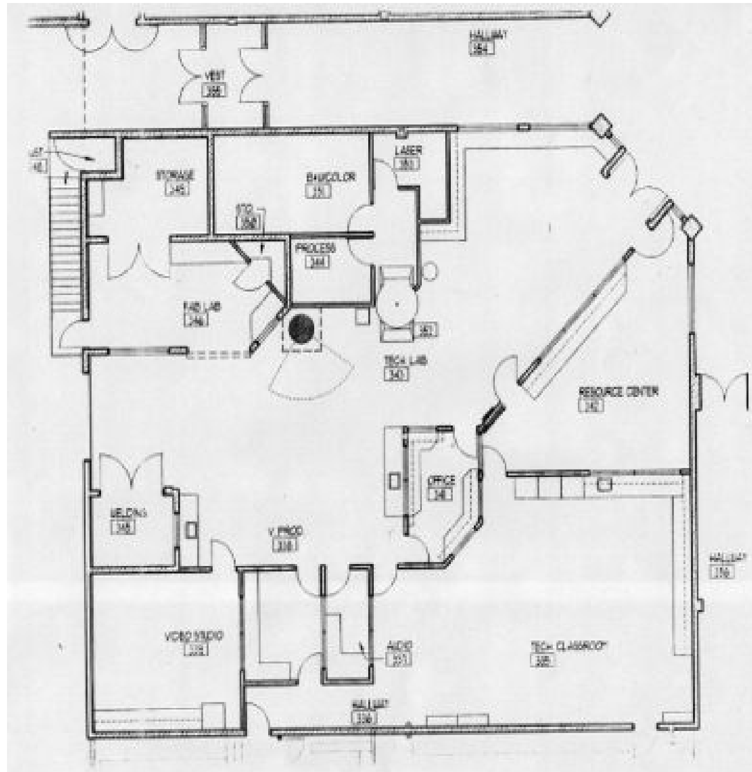
6th Grade Tech Curriculum 2001

Assignment
1. Floor Plan
2. Robotics
3. Clean Room Robot
4. Animation
5. Measurement
6. Product Design
7. Injection Molding
8. Morph
9. Flight Simulator
10. Interactive Physics
11. Radio Broadcasting
12. Electrical Safety
Tech ID
Robot Communications
Super Conductors
GPS
Electric Car

The entire instructional process is not just chaos. Students are all taught through direct instruction when an activity is introduced. but after the introduction, the time and date of when they complete it or work on it is their choice and responsibility. A typical class session begins in the classroom where new activities are introduced and/or announcements made. Following the brief teacher lead discussion giving updates and announcements, the familiar "Get to work" is announced and within 20 seconds desks are cleared and students scatter into various parts of the lab to do their work. Though this is typical, if Brad announces to the students they will be learning about a new technology on that particular day, students are not turned loose immediately. Rather, a new "tech note" sheet is passed out, objectives are identified, and students take notes while he describes the requirements, makes real life connections to the activity with stories, and illustrates how this particular technology is used and impacts our society. When the activity has been sufficiently explained and demonstrated the students are then sent to work and once again they choose which activity they will begin with. The pedagogy is based on the knowledge that students must structure their own information to make learning meaningful and activities are varied to allow for multiple intelligences to emerge.

This nonlinear theoretical foundation of learning guides not only Brad's instructional practice, but the facility, and assessment as well. Brad spent 25 years transforming an old woodshop into a renowned technology lab and in 1996 was able to design a new facility as a new school was built. It's 12 rooms stretch out over 4,000 sq. ft. of space. The rooms include a laser darkroom, clean room, resource room, fabrication lab, welding lab, general technology working lab, a biotech lab, audio broadcasting room, video studio, production room, classroom, and an office. "Stepping into Brad Thode's gym-sized classroom is like stepping into a hands-on museum of science and technology" (Bossick, 1999). The assessment method, like the facility and curriculum, matches the model of learning presented in the program. Portfolios are used to document the work completed. The portfolios are competency based. The teacher reviews each activity with the student in a brief one-on-one discussion. The teacher reviews the documented work in the portfolio and asks the student questions to check for understanding. If the student demonstrates the competency in the documented work, and answers the questions intelligently they get it passed off. Students often document their work with video, pictures, or an actual product they have designed and built. Students of technology therefore are responsible for getting a certain amount of work done in a semester and are virtually free to work on what ever activity they want, when they want, as long as they abide by the safety rules.

WRMS Tech Lab floor Plan plan.



Findings

Within this stimulating environment, students appear to be learning not only technological skills, like how to operate and program a robot, manufacture CD's, and produce video programs in this class, but they are learning transferable skills, like how to solve problems, manage time, and be a self-learner. They are learning technological literacy skills like how to predict and test theories. They are learning how to design things and build prototypes. They are learning what technology is and how it will affect their future. They are learning about technological systems. They are also learning many fundamental competencies needed in the workplace like how to manage resources, work with others, manage information, and select and use appropriate technology. Finally, they are exercising thinking skills, reading and research skills, mathematic and English skills, and developing personal qualities such as self-esteem, integrity, and respect.

Though the case study only provides indicators of learning, much of the data gathered shows relevance to the stated benefits of a technologically literate individual as declared in the *Technically Speaking* document (NAE & NRC, 2002). Some examples are included in Table 2 below. In addition, the responses from the students in questionnaire format, interviews with former student groups, parents, etc. indicate that student interest in the subject matter being taught is extremely high. Students make connections to their interests in a variety of technological fields and are making connections with other correlated fields such as Science, Math and English. Brad is adamant that technology should be used as an integrator.

> The process of establishing links among the courses offered in school is almost always left to the student. We teach science and math in separate rooms, for example, and seldom explain how engineers might apply concepts from both disciplines to solve real problems. Aside from some interdisciplinary thematic approaches taught at the

> elementary and middle school levels, it is unlikely that other academic teachers will embrace the idea of a more holistic education. Technology education teachers are in a unique position in that our curriculum is often more flexible. We have the opportunity to present the 'big picture' to our students by using a nonlinear approach *that encourages both students and teachers to keep learning along with the explosion of technology* (Thode& Thode, 1997).

Through such an embedded approach, Brad ensures he teaches the three "R's" as well. For instance, if a student turns in work without complete punctuation at the beginning and end of each sentence, the paper is thrown away. Math problems and reading are situationally intergraded much like life is like calculating and laying out a design or researching robotics.

Table 2

Technically Speaking: Benefits of Technological Literacy	**Wood River Middle School Technology Student Questionnaire Responses**
Improving Decision Making: Be better prepared to make well-informed decisions on matters that affect or are affected by technology. Increasing Citizen Participation: Be able to help make technological choices for the country as a whole or for some part of it. Supporting a Modern Workforce: Find it easier to learn the skills needed for jobs in today's technology-oriented workplaces, encourage students to pursue scientific or technical careers, and lessen our dependence on foreign workers to fill jobs in many sectors.	Do you think Mr. Thode is a good Teacher? "Yes, He knows when to teach you and when to let you find things out for yourself." What do you like about Mr. Thode's Teaching? "I like that he never really tells you the answer. He shows you or tells you how to find it." What is Mr. Thode trying to teach you? "I think he is trying to teach us about how technology has changed over time and what it will bring in the future." "He's teaching us about the real world, responsibility, and technology." What are you learning? "How we couldn't live without technology." How will it help you in the Future? "To know what is happening in the world for later in life." "It will give me knowledge about the technology I might use" "In every way my life will someday depend on how much I know about technology. It may even hold my career." "I want to become a engineer and that is what I have mostly learned in this class."
Technically Speaking: Why All Americans Need to Know more about Technology (NAE & NRC, 2002).	*Teaching Technological Literacy Through a Nonlinear Approach: A Case Study of Exemplary Practice. (Berrett, 2003).*

Significance

John Dewey wrote that in a democratic society one aim of an education is to "enable individuals to continue their education – or that the object and reward of learning is continued capacity for growth" (1944). He discussed how "Aims" by their general nature are a statement of emphasis at a given time of society and education. It is evident that at this time in the history of humanity there is a societal need for a technologically literate citizenry, not only for an improved citizenry, for addressing the needs of a new workforce and improved decision making, but also for this field, to draw student into the possibilities of making a career in engineering and technology. A letter sent to Brad dated March 1, 1999 from a former student now working for a civil engineering firm in Arizona, indicates that the experience in middle school and the method of teaching he experienced was essential for his success.

> Brad, when I stop and think of where I am now and the things I have accomplished in my life so far, there are not many aspects that aren't touched somehow by you and your classes. I truly try to remember all of the different skills and I find that there are too many to count. And it's not just the skills that matter. Your confidence in me and the other students to let us try, and fail, and succeed is a lifetime learning process that I can now pass onto my children… When I sit down to tackle a challenge, I am reminded of the myriad of problems and challenges which you offered to me and the other students in your class. My co-workers are always telling me that they are amazed at how a new challenge does not faze me. Most people I work with would rather just stick to the things that they know and not go outside their self imposed limits. So when I jump at the chance to try out new software, or come up with a new, more cost efficient and time saving way to complete a task which they do every day, people can't believe it. That confidence level is in no small part thanks to you.

Jerry Yeargan, engineering professor at the University of Arkansas and 2001 President of ABET, suggested that creating standards and teaching technological literacy is "not about getting more students into engineering, its about getting the right students into engineering." (Gorham, 2002) By teaching technology for all, like Brad Thode does in Wood River Middle School, perhaps we might better encourage young engineers and achieve a more technologically literate citizenry.

Conclusion

Though this paper represents a sliver of a view into the case study of Brad Thode and his teaching practice, I hope it has served a purpose of creating interest and opening up minds to the possibility of elevating the education of our children to the highest potential of technological literacy. You don't need a super perfect facility, or a large endowment of money to begin doing things that Brad has done. This example should simply serve as a place to find good ideas to build upon. As you do, you should consider 5 fundamentals that I believe Brad has built his program on: 1) Think outside the box, 2) Create a culture of learning, 3) Establish a lived curriculum. 4) Establish philosophical foundations, and 5) Meet the demands of teaching. In addition I would encourage all those involved to review the *Standards for Technological Literacy: Content for the Study of Technology* published by the International Technology Education Association (ITEA). This book presents a "vision of what students should know and be able to do in order to be technologically literate" (ITEA, 2000).

If you are still looking for a place to begin, perhaps you might be interested in learning more about the curriculum, facility, philosophy, or outcomes of Brad Thode's teaching from the full case study available at http://www.et.byu.edu/tte/berrett/research. A 30 page executive summary manuscript is also available there. The bottom line however, is to look inside yourself for the innovation and creativity you poses to make your learning environment more stimulating, real world driven, and meaningful to the students you have the honor to engage. Begin to question your own thoughts about what might work better in teaching technological literacy. Having an exemplary program is not about the facility itself, rather its about thinking of the possibility of "other"…the possibility of doing something "other" than you are doing right now. Ask yourself "what do my students really need to know?" Ask yourself, "what do I believe about how students learn?" Does your current curriculum and teaching method match your beliefs? If not, why not change?

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