Constructivism and the Use of Technology

The continued use of traditional teaching methods has resulted in an "estrangement" of our schools from society.

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Today, educational reform is a topic of much debate. The ongoing public discourse regarding reform is but a manifestation of the many changes our society is undergoing. The changes being brought about by the rapid technological advances of the last fifty years compel us to change our way of thinking and doing things, especially our way of educating as it relates to technology.

Riel & Fulton (1998) discussed the issue of educational reform and proposed that there are four central reasons for school reform:

a. "to prepare students for the challenges of a global economy,
b. to teach students who are underserved by current efforts,
c. to increase student performance on international comparisons, and
d. to change pedagogy, building on theories of effective learning."

The first three reasons for reform are directly related to the fact that a new global economy has emerged. This new economy requires new skills in the workforce, while opening up competition for jobs on an international scale. These reasons also deal with improving student performance in order to make them more competitive in the new global economy. The fourth reason for reform, changing pedagogy utilizing current theories of effective learning, is perhaps the most important reason for reform. Without effective teaching and learning, the first three reasons for reform cannot be met.

Behaviorism

During the last century the "knowledge transmission" model of learning has had the greatest influence over classroom teaching. This behaviorist methodology requires the transmission of facts from the

teacher to the student (Cuban,1993). The model holds that skills are developed by teaching small component skills that are then combined to form complex skills. Successful acquisition of skills is then rewarded with high grades, and unsuccessful acquisition is negatively reinforced with low grades (Skinner, 1949). This methodology deals with the student's retention of information but pays little attention to the understanding of the subject. It also does not consider whether the students are able to apply this information in different situations. The skills necessary in the new global economy are ones that require the application of knowledge. Skills such as critical thinking and problem solving are highly desirable in a global system that requires flexibility and adaptability. In a global economy, the ability to adapt and quickly resolve problems can be the difference between success and failure. These sorts of skills and abilities are not easily taught using knowledge transmission pedagogical methodologies; they are best taught using methods that stress the application of knowledge.

Strommen (1992) described the enormous changes that have taken place in our society over the last twenty years as new technologies have become commonplace. The school children of today have grown up with interactive electronic entertainment, computers, and televisions. They have grown up in an environment in which they control information flow and access, whether it is by remote control, video game controller, or computer mouse. This manner of obtaining and controlling information has dramatically influenced the society in which we live, creating a new culture in which information is readily available and controlled by the members of society at large. "Such factors dealing with the use of technology make it important that decisions be made with care about any particular product or system." (ITEA, 2000, p.57) In a democratic society such as ours, individual citizens need to be able to make responsible, informed decisions about the development and use of such technologies.

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In spite of the changes in society due to advances in technology and the need for those in the workforce to be able to apply technological skills, traditional methods of teaching (such as knowledge transmission) are still the predominant methodologies taught to future teachers in some colleges and education departments around the country. The graduates from these institutions are much like their predecessors of decades before. Seymor Papert (1980) made the observation that the classroom is one of the few places of human activity where someone who had slept for 200 years could wake up and return and still feel comfortable. The continued use of traditional teaching methods has resulted in an "estrangement" of our schools from society. What is needed is major school reform in which technology is used effectively in educational settings to enhance student learning. Strommen made it clear that in order to affect this reform, principled changes in the curriculum are needed.

Constructivism

A theory of teaching and learning that does address the issue of knowledge and the application of knowledge is the theory of constructivism. Constructivism is a theory of knowledge-building based upon the pioneering work of Jean Piaget and Lev Vygotsky. In constructivist theory, knowledge is "constructed" by the learner, not simply acquired by a mere act of transmission of information from the teacher to the student.

Piaget's theories lead to the conclusion that learning is not something that is "received" from someone (i.e. the teacher), but learning is "constructed" by the learner. Learning is therefore achieved through active engagement by the learner. This active engagement is dependent upon the learner's prior knowledge. Constructivist learning therefore requires the learner to construct new knowledge or understanding using an active process that relates or builds upon previously acquired knowledge.

Lev Vygotsky's work revolved around 3 concepts:

a. the zone of proximal development,
b. scaffolding, and

...cognition is not an isolated process but occurs in cultural context.

c. the sociocultural nature of learning.

The zone of proximal development describes an area or situation in which a learner would have trouble solving a problem on his/her own but would be able to do so with help from someone more knowledgeable. The concept of scaffolding refers to the process of providing support during the learning process and then slowly withdrawing the support as the learner gains the ability to deal with the task. This support can be in the form of "cooperative learning among peers, guidance from adults, well-structured learning environments, or strategies for helping students organize new material and relate it to prior knowledge." (Bissell, 1998) Lev Vygotsky's work made it clear that cognition is not an isolated process but occurs in cultural context. In recent years the concept of learning as a social and collaborative process has gained increased interest by researchers (Riel & Fulton, 1998).

Constructivism is a powerful theory of learning that holds great promise for educational reform, and many educators would agree that constructivist teaching methods can greatly improve learning. Constructivist theories and methods can also be used in different settings and situations. Technology education is an example of a discipline that can effectively use constructivist teaching practices through its use of laboratory-classroom learning activities that allow students to apply academic knowledge.

Constructivism and Technology

Since the release of *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) the field of technology education has been looking for direction in implementation. Bybee & Loucks-Horsley (2000) stated the following:

> The release of Standards is only the first step in the journey of educational reform. If the Standards are to be realized in curriculum, instruction, and assessment, then the communities directly involved in these activities will have to assume responsibility for seeing that changes are implemented. The Standards cannot directly change behavior or beliefs, but they can point the way by defining desirable goals, stimulating movement toward the goals, and reducing conflicts among the policies under which educators at each level labor. (p. 32)

Some type of reform in technology education will be dictated by the Standards, but what will be the best method for implementing them? If the traditional teaching style remains the same, will the students benefit from implementation of the Standards? Pressure to properly assess students' work while using the Standards as a base for curriculum development is a concern.

Technology education already has a good starting point in the area of reform because technology education has traditionally embraced a laboratory format in which students have been able to apply knowledge and skills in meaningful ways. With this said, the profession requires continued progress towards the end result of constructivist practices using technology.

Standards for Technological Literacy (ITEA, 2000) states the following:

> One of the great benefits of learning about technology is also learning to do technology, that is, to carry out in the laboratory-classroom many of the processes that underlie the development of technology in the real world. Recent research on learning finds that many students learn best in experimental ways—**by doing** rather than only by seeing or hearing—and the study of technology emphasizes and capitalizes on such active learning. (p.5)

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This statement could imply a constructivist attitude by the authors of the Standards. Teachers and teacher educators should initiate change in the way students are presented with and acquire information, away from the knowledge transmission model.

Henry Jay Becker (1999) discussed the effect of computers on teachers' pedagogical practices and believed that neither teachers nor school cultures are static. Education takes place in a climate that "encourages, pressures, or even demands that teachers modify their teaching styles and even their underlying beliefs about good teaching." (p.1) He stated that the current discourse in education is one that addresses and encourages the use of constructivist teaching and learning practices. These constructivist-compatible practices are threefold:

a. tasks,
b. curriculum, and
c. teaching style.

The following criteria should be followed:

1. Tasks should be connected to real people and situations while allowing for student interests in the classroom.
2. Tasks should facilitate student exploration without the need for constant direction.
3. Tasks should be projects that require integrating diverse skills over several weeks.
4. Curriculum should be thematic and interdisciplinary—allowing for deep, more meaningful exploration instead of broader coverage.
5. Teaching style should emphasize collaborative learning that requires students to take initiative.
6. Different students should be allowed to work on different activities during one class.
7. Teachers should be seen as learners and not just a source of information.
8. Teachers should also be encouraged to become reflective about their teaching and learning processes.

Teachers themselves need to be involved in activities and/or in-services which help them gain a better understanding of such topics as technological design, engineering design, problem solving, and teamwork.

Standards for Technological Literacy (ITEA, 2000) included several recommendations that promote constructivism:

1. Include experiences and activities that enhance and promote hands-on learning, including problem-based and design-based learning. These experiences and activities also should be open-ended, requiring students to develop and use technological thinking and challenging them to use and apply it in a variety of settings.
2. Incorporate knowledge and process activities that enable students to think and do for themselves, as well as to be effective team members.
3. Include activities that demonstrate to students the need to be adaptable.
4. Provide opportunities for students to demonstrate their understanding of technology and its value to them and society.

Compare a constructivist educational style to some of what *Standards for Technological Literacy* recommends that teachers be able to implement. Both Henry Jay Becker and the Standards called for students to be involved in learning experiences and situations that encourage them to apply their knowledge in meaningful, real-life situations, situations that permit students to work together to discover and solve the problems which they may encounter, and to build and refine their knowledge and skills through their own work.

Becker (1999) also discussed the resources that are necessary in order for teachers to institute constructivist-compatible practices. These resources included information resources, social support

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resources, and educational resources for students. The information resources should supply "opinion, reasoned argument, and factual knowledge" (p.1) that allow teachers to reflect on pedagogical goals and objectives. The social support services should involve a supportive school environment that is conducive to teachers helping each other both individually and in networks. This support allows teachers to gain knowledge of how to affect change through examples, models, and advice. The educational resources for students should entail "materials, equipment, and information and communications resources that students themselves need in order to engage in new types of tasks, address new learning objectives, and be the kind of student called for by constructivist theories of learning." (p.2) Therefore, in order to successfully implement constructivist compatible practices all of these resources must be present.

Teachers themselves need to be involved in activities and/or in-services which help them gain a better understanding of such topics as technological design, engineering design, problem solving, and teamwork. One example of a professional development opportunity that does this is when high school teachers spend several weeks during the summer with laboratory engineers, working on their teams and participating in their ongoing research and development. As teachers work as partners to the engineers, they develop new design abilities, come to understand the process of technological problem solving, appreciate the dead ends and uncertainties of engineering, use new technologies, and examine the engineering and design literature. Teachers deepen their understanding of technology, build their design abilities and understanding, and do so through their participation in actual problems. (Bybee & Loucks-Horsley, 2000). This type of experience would provide teachers the resources for which Becker (1999) calls.

Implementation of Constructivism

To successfully implement constructivist teaching practices, a paradigm shift will be necessary for many educators. Even today, many teachers use instructional methods that facilitate the use of a conventional classroom in a cloistered set of buildings with rows of students facing the "teacher" who has prepared the lesson he/she thinks is important. It creates an environment that tends to ignore higher order learning skills such as creativity, independent thought, inquiry, research, leadership, and innovation. Serving as a successful mentor in a new paradigm will require new teaching techniques in design, facilitation, and counseling. For example, a faculty member, or group of faculty members, may collaborate with a software developer to create a mathematics game enabling students to use their mathematics skills to design various mechanical devices. Improper calculations would result in machine simulations that break down, requiring the student to locate and correct his/her design flaw.

Under the constructivist paradigm students may be involved in facilitating learning experiences, such as the creation of an on-line conferencing process where students are engaged in joint research with a participating company. Students would publish their research findings in an online journal, offer critiques and questions about each other's findings, and be challenged by the faculty facilitator who plays the role of the business interest that commissioned the research. Many teachers have reported that this sort of real-world problem solving helps students with their other courses by making the subject matter meaningful to them. The best way to learn something—to truly master and retain it, not just to learn it well enough to pass a test—is to apply it.

Another example of the union of constructivism and technology being implemented in the high school classroom is the High Mileage Challenge held at Utah State University. Through the Industrial Technology and Educa-

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tion Department, area high school teams participate in a hands-on application of technology.

The purpose is to design, engineer, and fabricate a one-person vehicle in accordance with a set of established guidelines for construction that is capable of achieving very high mileage using a small gasoline engine. These vehicles navigate a course (approx. 7 miles) while trying to use as little gas as possible. Participants compete for prize money, traveling trophies, and ribbons.

Specifically, the objectives of the competition are

a. to provide a challenging activity for technology education students in which they apply problem solving, design, and safety skills,
b. to introduce students to an interdisciplinary application of skills, and
c. to promote teamwork in the completion of a project. In the building of their vehicles students have to use a variety of manipulative skills, math, physics, and energy conservation.

A portfolio is also required with each registration that includes

a. an explanation of the various disciplines involved (math, science, English, etc.),
b. written and illustrated documentation of the design and construction of the vehicle, and
c. explanation and documentation of public relations efforts conducted.

Portfolios reinforce the learning that takes place during the entire project. This activity uses constructivism and authentic assessment during the process.

Standards for Technological Literacy (ITEA, 2000) calls for teachers to involve students in constructivist-compatible activities such as technological design. Because technological design involves practical, real-world problem-solving methods, it teaches valuable abilities that can be applied to everyday life and provides tools essential for living in a technological environment.

Constructivism is a concept that may be implemented at every grade level, just as the Standards were written to be implemented at every grade level. At the elementary level, teachers involved in an assembly line activity with first graders found a successful joining of constructivism, technology, and meaningful assessment. Kirkwood & Kendrick (1999) stated the following:

> Constructive hands-on learning activities give children concrete understanding of abstract ideas. In the wonderfully busy world of the elementary classroom, elementary school technology education (ESTE) activities provide realistic settings where teachers can readily assess the learning of their students. When children work and learn through hands-on activities, they produce evidence of solutions to problems. In assessing progress and the outcomes of an ESTE activity, we acquire a unique view into children's minds. We begin to learn how they process informaiton and solve problems. Assessing children's learning in realistic settings is often called authentic assessment. (p. 12)

Evaluation/Assessment

The changes brought about by the implementation of constructivism, by having students involved in activities and projects that promote the application of skills and knowledge, will, in turn, require that students be assessed by methods other than the traditional true-false, fill-in-the-blank or multiple-choice tests. *Standards for Technological Literacy* (ITEA, 2000) stated that resources made available to those teachers implementing the Standards should:

> Provide opportunities for students to demonstrate their understanding of technology and its value to them and society, and include experiences and activities that enhance and promote hands-on learning, including problem-based and

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> design-based learning. These experiences and activities also should be open-ended, requiring students to develop and use technological thinking and challenging them to use and apply it in a variety of settings. (p.19)

Such activities call for students to be assessed in more meaningful, less traditional ways. Journals, products, and displays may be better instruments by which to measure student understanding and progress.

Additionally, if one adheres to the Standards' definition of assessment, one can begin to see the implications for changes in assessment. The Standards define assessment as "an exercise, such as an activity, portfolio, written test, or experiment that seeks to measure a student's skills or knowledge in a subject area." (ITEA, 2000, p.236) One can see that the way in which students are taught is a natural method for assessing them. For example, asking students to reassemble a lawnmower engine is a more powerful and meaningful tool for assessing their understanding of the task than is answering true-false questions. Therefore, a constructivist attitude in helping students learn and acquire information leads to a constructivist attitude in assessment. This change in attitude allows students to demonstrate their ability to apply their understanding of information and skills in meaningful, real-life ways that comply with given criteria. Students at the high school and university level may also be involved in self-assessment, monitoring their own learning and the viability of the products that they may produce, just as engineers and technological designers are required to do in the workplace.

Technological design also promotes teamwork as a method by which people work together to accomplish a common goal. If students know how problem-solving methods work, they can gain a better appreciation and understanding of technology. (ITEA, 2000)

Because of the capacity afforded by constructivist teaching to make learning more outcome oriented, opportunities for accelerated learning will multiply. A new generation of learners will become accustomed to deciding when to learn, how to learn, and even how their progress is to be certified.

Educational reform is an important issue in modern society. There is currently considerable political educational debate concerning the types of reform that are needed and the best ways to achieve these changes. The reasons for reform are numerous, but most reform issues revolve around the need (either directly or indirectly) to prepare students for success in the new global economy. The new global economy is a product of the information/communication age in which we now find ourselves. *Standards for Technological Literacy* (ITEA, 2000) implies the use of constructivist methods in both the manner in which students are to acquire skills and knowledge and the manner in which students are to be assessed. If students are expected to be able to perform in a society that demands that they be able to apply their knowledge in national, international, and global situations, then we as instructors must be prepared to teach them in a manner that advocates learning by trying, testing, modeling, and doing. This is instruction based on constructivism.

Technology education as a discipline must further develop curricula that utilize constructivist practices while being guided by the Standards and authentically assessing students throughout the process. Success in this new age depends upon the skills and knowledge levels of our citizens. Therefore, we must reform our schools to produce

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students with skills to meet the high expectations of the next millennium.

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