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Features

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Commentaries

Project
KID DESIGNER

Constructivism at Work through Play

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Introduction

School learning is a difficult, time-consuming process requiring deliberate effort and commitment. Schools expect children to learn a great many things about hundreds of topics traditionally categorized by subject areas. But why are certain things taught in schools and not others? Why do we expect all students to know the same things about so many topics? Why isn't it acceptable for one student to concentrate more on mathematics and another on social studies? And why do these subjects have to be taught separately? There are questions, usually unspoken, that teachers and students often confront. After all, if it wasn't important to know, it wouldn't be in the curriculum, right? An interesting question that can trap many teachers in a circular argument - if it is in the curriculum, it must be important to know and only important things to know are in the curriculum. Students look to teachers not only for guidance on how to learn, but also for reasons why to learn. It's hard to explain to a fifth grader why they have to learn about Roman numerals. Explaining that you need to learn how to add fractions because "someday you will need to know this when you get a job" carries little weight with most children. They see school as their job. The best reason they know of to try to learn these things today is that there will be a price to pay if they don't - a poor score on the next test.

But many students do not care about things like test scores, Roman numerals, or even books that adults call literature. Those who do care often do so simply to please the teacher or their parents. While many children have difficulty in school due to physical or learning disabilities that are beyond their control, others do poorly because they do not take school work seriously. As a result, schools label these children, normal in every other way, as "at risk," "underachievers," "problem students," "disruptive," etc. Perhaps most disturbing is the conflict that arises between children who are and are not successful at school. Knowing the answers and pleasing the teacher risks the loss of standing and position among one's peers. School ought not to be this way. Hard work and creative ideas should enhance, not threaten, one's self-esteem and social standing.

Children's lack of motivation to "achieve" stems from them not seeing school tasks as authentic and meaningful. When you put yourself in their position it is easy to agree with them. How authentic is getting a score of 80% or 90% correct on a test? How meaningful are answers to questions that the teacher already knows? An authentic, meaningful task is one that matters to a person at this moment. It is a problem or situation that has a purpose or goal that impacts one's life now, not later. It probably does not have a ready-made answer or solution, but instead demands much effort and hard work. What tasks or situations do elementary and middle children find authentic and meaningful? While there are undoubtedly many things to include on this list, we have chosen to focus on one - games.

The purpose of project KID DESIGNER is to enhance the natural tendency of children to explore their environment through play. We view play as a lifelong learning process, one that should not be neglected as we grow older (Pellegrini, 1995; Rieber, 1996; Rieber, Smith & Noah, in press). In this project, children have designed their own educational computer games that embed content from subjects they are studying at school. Rather than considering a game as a mere entertaining diversion for children, we consider games, and especially the act of game design, to involve sophisticated intellectual skills. Game design is a difficult problem-solving process requiring great effort and creativity. Having children design and play games to learn about subjects in school is simply asking them to call upon the same strategies that they naturally use to learn about the world outside of school.

A premise of this project is that the creative investment one takes in the design process leads directly to intellectual "ownership" of the game's content. Rather than viewing the subject matter taught in school as disconnected and unrelated to anything more meaningful than passing an approaching test, what Perkins (1986) calls "truth mongering," game design provides students with a relevant context for adapting content for a useful purpose. This is similar to the not so surprising phenomenon that if you want to learn something well, teach it. Teaching is but one form of design. Similarly, game design appears to be an activity that requires active engagement, reflective thought, and deliberate effort in order to transform content into game material.

In this paper we describe the theoretical and philosophical assumptions upon which Project KID DESIGNER is based and the procedures we have followed. Most important, we also provide an overview of the games produced by children to date and consider what these games represent in terms of learning, children's values, and the collaborative design process between and among the children and adults who have participated. Fortunately, the web based format of this article allows you, the reader, to actually play the games the children designed.

Theoretical and Philosophical Background

This project has been influenced by several theoretical frameworks - psychological, epistemological, and social. The project is constructivist in nature, a term used metaphorically (and often times haphazardly) in education to refer to learning as a process where individuals construct their own knowledge through meaningful interactions with the world. Learning is considered an active, controllable process that builds upon a student's prior knowledge and is grounded in meaningful, social contexts (Hooper & Rieber, 1995). This view is contrasted with "transmission models" of education which view learning as passing knowledge from one person (e.g. teacher) to another (e.g. student) (Grabinger, 1996). Modern interpretations of constructivism have been influenced by the work of Piaget, Vygotsky, and Dewey (see Duffy & Cunningham, 1996, for a review). Play and imitation are central to Piaget's notion of equilibration, a process based on the tension of living in an ever-changing environment while seeking an ordered, balanced world (Piaget, 1970). Play supports the assimilation of new ideas into a person's existing knowledge structures, whereas imitation supports accommodation, a process which expands a person's cognition as they build new knowledge structures which do not fit already existing structures (see Phillips, 1981, for a good review of Piaget's theory).

Piaget's theories are often criticized for neglecting the social aspects of learning. Vygotsky's work is often presented in contrast to Piaget's, though their approaches are far more complementary than adversarial (see Fowler, 1994, and von Glasersfeld, 1993). In fact, we have found it useful to blend Piaget's idea of how an individual constructs understanding with Vygotsky's ideas of social learning, such as Vygotsky's construct of the zone of proximal development (ZPD) (Vygotsky, 1978). According to Vygotsky (1978), ZPD "is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). This implies that individuals on the threshold of learning may be unable to do so without the aid or support from others. The extent to which one's knowledge can exist apart from its social context is a constant source of controversy (see Garrison, 1995).

The educational philosophy of John Dewey (see also John Dewey Links) has also influenced us, especially his progressive views of democratic forms of education (Dewey, 1916). Students should have a say in what they learn and how they learn, what Papert (1993) refers to as the "right to intellectual self-determination" (p. 5). This does not mean that education should be a "free for all" without purpose, goals, or expectations. Indeed, these expectations come from both sides of a student's desk. In a democratic learning environment, students do not decide for themselves what will be learned, but rather have varying degrees of choices in negotiation with the teacher. As students show they can make choices responsibly, they are given even more latitude. Likewise, it is reasonable for students to expect school to be a place where they will be engaged in meaningful activities that connect to their lives in honest ways. It is not reasonable for school to ask students to postpone relevance to some distant, future time. School is not preparation for life, but a part of life itself.

Democratic ideals are rarely practiced by schools. As Glickman (1996, p. 11) notes, "The contradiction is that the public school is the only institution with an explicit democratic purpose, yet it shows in its everyday educative actions and decision making among adults and students that democracy is not a practiced belief. .... Instead, one finds most schools composed of advisory groups or site-based councils of positional authority making decisions for everyone else." Even the term "progressive" has been a source of misunderstanding. As Garrison (1995, p. 731) notes, "...what Dewey meant by progressivism is that progressive societies grow while other kinds merely reproduce themselves." While Dewey's relevance to current educational problems should not be overdone (Paringer, 1990), his fundamental ideas of learning through democratic and social means seem as true today as they were at the beginning of the twentieth century.

The inherent technological grounding of this project is most directly related to a particular instantiation of constructivism referred to as constructionism, a word coined by Seymour Papert (1991) to suggest another metaphor, that of "learning by building":

> "Constructionism - the N word as opposed to the V word - shares constructivism's connotation of learning as 'building knowledge structures' irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe" (p. 1).

The act of learning by building is both a personal and social act. On one hand, transforming one's understanding of a domain into an artifact suitable for public display is evidence of an individual's cognitive processing. However, building something also provides the opportunity to get (and anticipate) feedback from one's peers, teachers, and parents, thus promoting relevancy before, during, and after the construction process. The range of things that one can build an put on public display is large. Traditional artifacts have included over the years such things as essays, term papers, and papier-mâché models. More recent examples include multimedia reports and presentations. However, as more children produce computer-based multimedia projects, there has been a tendency to shift the focus toward the technology itself (the graphics, sounds, and animations of the project) and away from the design process, leading educators and parents alike to justly wonder what do children learn from these projects (Troutner, 1996).

A possible answer comes from Perkins (1986, p. 5) who suggests a model of "learning by designing" based on four questions: 1) What is its purpose? (i.e. what is it for?) 2) What is its structure? (i.e. what are its parts, what is it made of?) 3) What are model cases of it? (i.e. what are some good examples?) and 4) What are arguments that explain and evaluate it? (i.e. how does it work? how good a job does it do?). With these four questions, the depth and utility of learning can both be directed and evaluated. Perkins asserts that if a person is unable to answer all four questions for something they have learned, then that knowledge has limited use or application (also called "inert knowledge," a term first coined by Whitehead, 1929). Interestingly, the four questions apply equally well to everyday objects (e.g., screwdrivers) and also school knowledge (e.g. the Pythagorean theorem). Schools typically focus most attention on question two, the structure of content, but rarely ask students to understand the purpose of knowledge, nor ask them to evaluate the usefulness of knowledge. This might be one reason why students have such a difficult time with history. Memorizing names, places, and events without knowing their relationship to other historical events, let alone to people's lives today, leads to decontextualized "factlets." We contend that to produce a good game, one must be able to answer all four questions.

Children learn in the context of authentic settings drawing information from their lived and often shared experiences. Many of these experiences occur outside the walls of the K-12 school and serve as powerful mediators for learning, much more so than contrived activities that accompany text and workbooks. As Brown, Collins and Duguid (1989) assert, "any method that tries to teach abstract concepts independently of authentic situations, overlooks the ways understanding is developed through continued situated use" (p.33). Children learn from their interactions with the world and from activities that are both challenging and personally meaningful. One way in which children participate in challenging, meaningful and enjoyable activities is in the playing of games. In engaging ways, games provide children with opportunities to learn skills and processes that schools identify as essential. Beyond the subject matter, many states (such as Georgia) have curriculum standards that include the development of problem solving skills, working with and respecting the views and ideas of others, and effectively communicating ideas (see http://admin.doe.k12.ga.us/gadoe/qcc.nsf for more information on Georgia's standards). These skills and abilities are all essential in the process of game design.

Not surprisingly, one common thread among children of various ages, genders, and backgrounds is the enjoyment of games. We found this to be true of all the elementary school students with whom we have worked. In our discussions about games and game playing with these students, they appeared almost alarmed that we were conducting a "formal" class discussion about what they undoubtedly considered "play." Certainly, to children of this age play is a meaningful pursuit. Games which they play or invent create an authentic and real experience into which they, generally, become immersed.

Although games have a long history in education (Dempsey, Lucassen, Gilley & Rasmussen, 1993-1994; Randel, Morris, Wetzel & Whitehill, 1992), they are, unfortunately, often associated with entertainment either as a diversion from school work or as a reward for when the work is done. The motivational appeal of games is well known (Malone & Lepper, 1987). However, limiting the discussion to motivation is apt to designate the role of games as a form of educational "sugar coating" - making the hard work of mathematics or language arts easier to "swallow." We take games much more seriously as we consider both their motivational and cognitive elements. Whereas most children play prepackaged games in school given to them by teachers, we are interested instead on the process of game design itself and how it can enhance learning.

Schools typically rely on extrinsic motivation, or incentives externally provided (such as grades, praise, and even threats of punishment). In contrast, intrinsic motivation is based on a person's own curiosity, interests, and values (Deci, 1985; Lepper, Keavney & Drake, 1996; Lepper & Malone, 1987). Perkins (1986) notes that it "seems much easier to undermine than to amplify" activities which are intrinsically motivating (p. 116). Intrinsic motivation characterizes students engaged in meaningful pursuits. Perkins lists five factors known to foster intrinsic motivation among students: 1) the project itself has intrinsic worth; 2) the students are personally in control of the project; 3) the project stimulates a sense of competence; 4) the students work under"optimal challenge" (the task is not too difficult or too easy); and 5) the activity in and of itself is enjoyable.

Project KID DESIGNER encompasses all five factors. The students were freed from the fear of evaluation of their project. They worked to satisfy their own criteria of what was good and what was not so good in their game design. As we will discuss in more depth later, the students themselves were empowered in this game design process. They readily accepted the responsibility and the ownership of the project. The students' confidence in their own ideas and abilities grew as the project unfolded. Through this stretching of their abilities, we believe that most students were "optimally challenged" by the game design project. Certainly, the students found the process enjoyable.

Much of the work carried out in this project reflected aspects of Csikszentmihalyi's (1990) Flow Theory. Simply defined, "flow" is the state in which we are so involved in something that nothing else matters. Csikszentmihalyi theorizes that experiencing flow activities, activities in which we are challenged, focused, and intrinsically motivated, pushes us to the extent of our present abilities and helps redefine us as more complex individuals. Additionally, these optimal experiences improve the quality of our life. Cultures, historically, have designed and played games to reflect the society's structure and roles; games provide practice for people to deal with conflicts typical to that culture in a nonthreatening way (Blanchard & Cheska, 1985; Roberts, Arth & Bush, 1959). We maintain that when designing games (and especially computer games) students construct their own "flow" experience. This was true for the children and adults who participated.

Project KID DESIGNER Procedures and Design Stages

The project has been conducted in four separate classrooms over the past three years. The project has been carried out with limited availability of computer hardware and software and under the typical constraints of public schools - compatibility and consistency with the existing curriculum, limited time, and the need to manage the project carefully so as not to disrupt the rest of the school day. The classes that have participated to date have varied widely. We label these classes 1, 2, 3, and 4 in the following sections to more clearly distinguish them (and to show the order in which they participated). Class 1 participated in January, 1994. It was small, consisting of only ten fourth grade students who had been labeled as academically "at risk." This class normally met in a computer lab. Class 2 involved the same teacher and school, but with different students a year later (February, 1995). Class 3 involved a different school and teacher. In contrast to the previous two classes, Class 3 was large, consisting of 34 fifth grade students, and only had access to the one computer permanently installed in the classroom. Class 4 participated in May, 1997 (same school as Class 3, but a different teacher). Class 4 was also large, consisting of 27 fifth grade students, and the teacher could only schedule limited time per week in the school's computer lab.

Each game was designed by a team of students with an adult assigned to support them and facilitate the design process. The actual programming of the games was done by the University of Georgia personnel using Authorware, a multimedia authoring tool by Macromedia. The project followed five design stages: 1) Orientation; 2) Identification of game design teams and brainstorming; 3) Generating a project idea; 4) Preliminary design; and 5) Final Design Stage. These design phases were followed in varying degrees of formality and the time taken to complete all the stages ranged from four consecutive school days to two months.

Orientation

Each of the five classes began the project with a class discussion on the topic of games. Students were asked to tell about games they liked and why they liked them. In each of the classes, the discussion flowed easily and all students were enthusiastic about contributing. This was a topic they knew something about. It seemed as though no one had ever asked them to talk about games, despite the amount of time they devoted to game playing.

Each orientation was concluded with one more question posed to the students: What makes a game fun? As any professional designer will tell you, this is not a trivial question. The answer involves a complex set of psychological and cultural variables. All students recognized the fundamental importance of the question - games are only worth playing if they are fun. They talked about games they consider fun now and also those they used to enjoy, such as games they played when they were younger. It did not take long for students to focus on the role of challenge, that a good game was hard, but not too hard and also that challenge is a dynamic variable in that it can change even while you are playing the game. As previously mentioned, optimization of challenge is a fundamental characteristic of intrinsic motivation (Keller & Suzuki, 1988; Malone & Lepper, 1987). This complex idea was well understood by all the students, at least tacitly. The orientation ended with students asked to think about games, especially good games, and how they might design their own games incorporating topics they were studying in school.

Although we expected the students to be very familiar with computer games, we were nonetheless struck by how pervasive computer games were in the lives of these children. These students were used to sophisticated 3-D graphics, sounds, and high energy scenarios. This was a technology with which all seemed to have experience. Interestingly, only with Class 4 did attention turn during the orientation discussion to the topic of violence in computer games. We were surprised by the matter of factness students spoke of about violence. One boy, though perhaps hoping for attention, boasted that "killing people [during computer games] relaxed him."

Identification of game design teams and brainstorming

Two teams were formed in Classes 1 and 2 and four teams were formed in Class 4. In contrast, all students in Class 3 acted as one team (this turned out to be problematic, as will be discussed later). The way each team was formed varied from class to class. Classes 1 and 2 were generally determined by the teacher according to where students sat in class, resulting in two teams for each class. The students in Class 4 were permitted to divide themselves into teams and they appeared to do so according to their already established peer groups sharply divided by gender. The result was four teams: two teams of all boys and two teams of all girls. Interestingly, existing social tensions surfaced in Class 4 undoubtedly due to the way teams were formed. For example, the teacher reported that originally there was just one team of girls (by chance, approximately two thirds of the class was male), but this team soon divided into two separate teams due to existing social friction. There was also one boy who seemed to be an outcast, apparently having been ostracized by his peers long before the project began. As a result, there was much tension and antagonism between he and his teammates from the start. **(See footnote[2])**

Once formed, the next step for every team was to meet and begin brainstorming possible game ideas, facilitated by an adult. Classes 1 and 2 were directed to design a game that was relevant to the science unit just completed (the laws of motion for Class 1 and understanding plants for Class 2). Classes 3 and 4 were not restricted in what content of the game covered in any way, though it was required that the game had to be considered educational - designing a game for entertainment purposes only was not allowed.

It became clear during the brainstorming that all students valued good ideas and it was interesting to watch how different ideas were evaluated by team members. Most teams had no difficulty in identifying a game topic quickly, probably because they had already spent considerable time thinking about it since the orientation session. The children also seemed a little surprised that their ideas were not being judged by the adults as good or bad, but that they were left to make the final decision. Negotiation did take place, but only in terms of what was possible from the programming standpoint. Many teams had ideas that originated from the computer games they had already played. For example, more than one team had wanted 3-D effects in their games and we had to sheepishly explain that our programming skills were not at that level.

Generating a project idea

Based on the brainstorming sessions, each team had to reach consensus on the general idea for their game. Students engaged in what Perkins (1986) has called problem finding. They were not trying to solve a problem given to them, but rather to create a new design. "Problem finding constitutes a crucial aspect of thinking characteristically neglected in instruction" (Perkins, 1986, p. 209). Students seemed to enjoy and be comfortable with the brainstorming process. Again, good ideas were recognized as so by team members. However, this stage was clearly most successful when a team consisted of 4-5 members. A team of this size generated sufficient ideas to keep the process moving, but not so many as to be overwhelming or confusing. This was the problem with Class 3 and resulted in many students in the class losing interest in the project undoubtedly because they did not feel part of the process (as it turned out, a small core of students took over most of the actual designing, although over half of the class still contributed in various ways).

Preliminary design

At this stage, it was important for the team not only to reach consensus over the general structure and purpose of the game, but also to effectively communicate this structure to the adult programmers. A prototyping process was used where a working model of the game was developed as soon as the fundamental game structure was established, even though few game elements had yet to be developed (e.g. graphics for the game objects). For example, if the design called for players to answer questions to progress through the game, the game prototype would have a "placeholder" for where the question would go. This allowed the students to see and play their game as it was being developed. The game prototype also provided the relevancy and authenticity for doing the actual development in the next design phase.

It's worth noting that the design of the games show an astonishing complexity. Most adults get quite confused when they read the directions to many of the games, not because the directions are poorly written, but because understanding the rules is quite a challenge. For example, click here to see the directions for "Maze of the Minotaur."

It's interesting to note that several of the other games use "money" as rewards: the lesson of the "value of a buck" has not been lost on these students.

Final design stage

This stage involved constructing or developing all of the game elements contained in the preliminary design. Students were responsible to generate all the game graphics (using KidPix or HyperStudio, depending on the class), write game directions, and whatever else was included in the preliminary design (e.g. game questions). Students found that this phase required hard work and deliberate effort on their part. For example, writing game directions is more difficult than it sounds. Though students could easily talk about the rules of the game and how it was supposed to work, transforming these rules into written form took considerable effort. Again, the authenticity of the task - all the students understood that games require directions - meant that the teacher did not need to invent a rationale for the writing. Writing game directions also turned out to be an excellent language arts activity for the students.

As another example, the preliminary game design of both teams in Class 2 called for questions about the parts of a plant and how plants grow, but at this stage they actually had to write the questions. Interestingly, research shows that having students generate their own questions is an excellent learning strategy (see Wong, 1985), but convincing students that they should invest such effort can be a challenge for a teacher. In this project, the students themselves decided they needed the questions and although they found writing questions difficult, they understood and accepted the task as important. Interestingly, the two teams in Class 2 decided to share questions, thus cutting the work load effectively in half - a creative, collaborative idea.

These design phases were followed in varying degrees of formality and the time taken to complete all the stages differed from four consecutive school days to two months. For example, the project was conducted the most formally with Class 1 and was essentially completed over the span of only four consecutive school days (more planning was done simply because this was the first class to participate in the project). Class 2 had the benefit of playing the games produced by Class 1. Therefore, they had a much clearer sense of the intended goals and outcomes. The project lasted for about three weeks with Class 2, but with about the same amount of class time formally devoted to the design process. The design process for Class 3 lasted for about two months and was the most difficult game design to manage simply because it was very difficult to reach consensus with so many students and so many ideas.

Having learned some valuable lessons from the first three classes, we used the design phases much more effectively with class 4. Not surprisingly, the children in all of the classes naturally wanted to use the computers as much as possible, even though many aspects of game design could be done well with paper and pencil (such as writing game directions, game questions, or sketching game graphics). They simply wanted to use the computer, partly due to its novelty and partly due to the feeling of being directly involved in creating computer games. This class had access to HyperStudio, another multimedia authoring tool, in their school's computer lab. Therefore, we constructed a "Game Designer Stack" using

HyperStudio to give students simple word processing and graphics tools set in the context of game design. Not only did they enjoy using the stack, it also clearly organized the game design process for them (it's important to note that these students had never used HyperStudio before, but quickly mastered the tool sufficiently to use this stack). The stack also made it much easier for us, as the programmers, to collect and manage the various game elements constructed by the students. Each student also had his/her own disk containing the game designer stack, thereby giving each student physical ownership of their contribution to the game project.

An Overview of the Games and Their Implications to School Learning

A total of nine games have been produced through the collaborative efforts of the four classes and adult facilitators. It is not feasible to describe any of the games in detail, rather we have chosen to briefly discuss some broad general outcomes. These outcomes are reflected in the games themselves and the events that surrounded the development cycle (i.e. the process where the game designs were built into working prototypes, and then refined in the final version). First, the games reflect one representation of how students perceive domain knowledge in a school's curriculum. Two, the game design and development process illustrate the act of collaboration between the students and also between the students and adults. Three, the project demonstrates an example of what students do when they are empowered with decision-making responsibilities.

It is reasonable to ask at what point did the children's input end and the adults' begin. Throughout the project, our goal was only to facilitate the children's ideas. However, compromises had to be negotiated as the games went into development. This is why we chose to use a rapid prototyping approach. It is difficult to know if a game design is appropriate until the game is played, even in crude form. This prototyping process allowed rich discussions to take place between the students and the adults. Students probably first recognized how seriously their ideas were being taken when they saw the first working prototype. Seeing and playing this first working example of their game provided real evidence that a group of adults valued their ideas enough to spend obvious and considerable time and effort to build the working prototype, followed by the students asked to critique the adult's work to ensure that the original design ideas were faithfully reproduced.

Given that this journal's mission is directed at middle school education and that our work thus far has been limited to upper elementary school students, it is reasonable to question the relevancy of the project's goals and findings to a middle school population. We recognize that middle school students have emotional, social, and cognitive needs which distinguish them from elementary students. However, we feel that Project KID DESIGNER supports the "middle school concept" through cooperative learning and as a project based activity (Rottier & Ogan, 1991). As previously noted, students work collaboratively with other students as well as with adult facilitators in designing their game. This is a flexibly structured situation which encourages the students to think, play, imagine, and create as a group. This type of academic experience fosters the student's sense of self-worth (Rubinstein, 1994). The students begin the project with simply an idea and end the project with a playable game; this tangible artifact of their work certainly represents a great deal to each individual student and to the collective group.

As a project based activity Project KID DESIGNER involves the application of prior learning, the organization of ideas, a positive interactive relationship with adults, and a process which breaks the project into small, well-defined stages. All of these characteristics encourage the middle school student to participate socially (with his/her peers and with adults) as well as cognitively. In addition, the project incorporates many of Doyle and Pimentel's (Doyle & Pimentel, 1993, January 13) "in" list: effort, mastery, autonomy, accomplishment, and authentic assessment. This focus on both the affective and the intellectual needs of the students seems to situate Project Kid Designer well within the middle school curriculum.

Student Perspectives on Embedding Content in a Game

One of the most important attributes of educational game design is how to embed content into the game fantasy. For example, Malone (1987) talks about a game's fantasy context to be either endogenous or exogenous to the educational content of a game. An exogenous fantasy is clearly separate from the content, such as popular "hang man" games. Any content can be superimposed on an exogenous fantasy and there is no mistaking the game from what is to be learned. Students play these games in spite of the educational value. In contrast, games with an endogenous fantasy blend or "weave" the educational content with the fantasy, such that it is not clear where to draw the line between learning and having fun. These are more difficult games to design. The children's game effectively show these two sorts of fantasy contexts. We have been quite impressed overall in creative fantasy contexts invented by the children for all of the games.

An endogenous fantasy is well illustrated in "Space Race," a game designed to teach about Newton's laws of motion. The goal of the game is to drive a "rig" around a race course in outer space, trying to get to the finish line as quickly as possible. One important concept that the students embedded into this game was the concept of mass and its relationship to acceleration. This is the basis of Newton's second law, where the force is equal to mass times acceleration (i.e. F=ma). This relationship also means that an object's velocity changes proportionally (i.e. acceleration) to changes to the object's mass (assuming that the force remains the same). If you are driving the small rig (less mass), it is easy to maneuver the rig because it responds more quickly to the controls. However, the small rig can be defeated by a roaming "alien," should they happen to meet, and the game ends. If you choose to drive the "big" rig (more mass) it will be less maneuverable, but it will defeat the alien if they meet.

In contrast, an exogenous fantasy is illustrated in "Super Cross," a game designed to teach math facts. The goal of the game is to ride your motorcycle to the finish line of three individual motor cross courses, each more difficult than the previous. Along the way, you have to successfully navigate several jumps. If you are going too slow (making it easy to maneuver) when you encounter a jump, you have to answer correctly a randomly generated math problem to proceed. If your answer is incorrect, you go back to the beginning of the course. This game was considered to be one of the most successful as evidenced by the number of other students in the class who wanted to play the game (mostly boys). But most would have preferred that the game not contain the math facts. This game uses mathematics as a penalty and we wonder how deep that perception may go for school subjects in general.

Most of the remaining games use questions as the means to bring other educational content, such as history and science, into the games. Questions are a standard way students experience and test their understanding of subjects at school. Also, all of the games require some physical action or manipulation on the part of the player, clearly an influence of video games. However, this also gives the player some level of control. Students seem to enjoy the physical challenge of manipulating game objects. Mazes appear in a third of the games. Mazes are a favorite game structure for children and lead to a variety of interesting game ideas.

Are games that children designed actually liked by other children? This is an interesting question that we have not as yet investigated. This project has concerned solely the constructivist activity of building games as a route to learning and social interaction. If the games turn out to be interesting and fun to other children, there is a secondary bonus, albeit an "instructivist" one, in that children can learn from playing games other children designed.

Collaboration

As the students in groups worked together, we were able to make a number of observations about the groups' dynamics. First, the group members became quite adept at the negotiation of ideas, decisions and the division of tasks. In an all-girl group, members democratically discussed the details and changes that effected the visual layout of their game. As this occurred, all voices were recognized and respected and eventually consensus was reached. Second, informally and almost spontaneously, a natural leader emerged that helped the group proceed through the design process. Although all members of the group made contributions on some level, they often turned to and deferred to the lead child when final decisions needed to be made. For instance, when the group members needed to decide on the size of a playing piece, the programmer gave them several options from which to choose. Subsequent to a brief discussion at which no final decision was reached, the group turned to their informal leader and asked, "What do you think?" When she gave her opinion, the group agreed on her assessment and went with her choice. It was of great interest that the students in the group chose to turn to their student leader instead of the adult programmer.

The last observation made about the inter-group collaboration was that the group recognized many of the particular talents of the individual members and matched tasks appropriately with these individuals. This supports Dewey's (1929) notion that "true education comes through the stimulation of the child's powers by the demands of the social situations in which he finds himself" (p.3). An example of this occurred in a group in which riddles needed to be written to add challenge to the game. The group collectively turned to one group member and said, "You like riddles and are good at them, so maybe you should write some for our game." The riddle-proficient student agreed to the task. Later, the adult programmer learned that the group member appointed to write riddles was considered a low-achieving student. The group superseded this school information about the child and instead relied on their knowledge of her in social and informal settings as evidenced by the statement "You are good at riddles."

Beyond peer collaboration, each student group collaborated with us as the programmers for their design. Initially, we felt the students saw us as three teachers; we were there to "instruct" them in game design. However, we hoped that in this role, we could be, as Perkins (1986) describes, "models of ignorance" (p. 219). As part of their group, students would make suggestions about how the game should look or how the user interaction should work. We would discuss programming possibilities and even explore potential approaches that were beyond our experience. Some of the possibilities they liked, others they modified. So indeed, after several weeks of dialogue, the students came to see us not as adults who knew all the answers, but as adults who were often puzzled by design considerations, but willing collaborators in search for solutions.

As mentioned earlier, students find that there are often social risks associated to knowing the right answer to a school question. Balancing success at school with peer relationships is a delicate matter. At the end of the project in Class 4, we noticed what we feel is a significant event that turned "knowing the answer" into a valuable social commodity. One boy was playing and enjoying "Super Cross," but he clearly did not know his math facts. Rather than give up the chance to continue playing, he turned to a boy sitting nearby for answers to the math problems. In this situation, the boy with the answers became important to his friend because he knew the answer.

Often, there are students in classrooms who, for whatever reason, remain on the outside. As previously mentioned, we witnessed this situation with Class 4 during our initial visit, noticing that one boy was ostracized and teased by his classmates. During the various stages of the design process, his suggestions were often dismissed by the team. However, near the end of the project, he made a very clever design suggestion which the other team members greeted with comments which included "that's a great idea," and "yeah, let's do that." Certainly, there is no way to measure what this did to his self-esteem, his standing in the group, or his own feelings of contribution to the process. But, for at least one moment, this pariah was not treated as the outcast. A good idea, in the context of an activity valued by a social group, has a way of leveling the "playing field."

Empowerment

Lincoln (1995) believes that "children are the primary stakeholders in their own learning processes" (p.89). Children can become deeply invested in their learning when they feel empowered to choose what they learn and the ways in which they learn. By collaborating with children to create a game that uses their ideas, the teacher is given a peek into the ways the students think and insights into what kinds of things matter in their lives. As Lincoln (1995) states, "Children and adults combine power and create new forms of wisdom when they explore learning together" (p.89). The process of designing a game becomes synergistic in that adult and students create a product (the game) while engaging in a process that strengthens the cognitive and affective (e.g. self-esteem) skills of the students. In working with the students in Class 4, we noticed gains in their ability to collaborate and negotiate with each other and the adult facilitators, as well as their ability to hone their organizational skills. They also appeared to gain confidence in decision making about the games progress and they recognized the need to clearly articulate these details to each other and the adult programmer.

At first, the students seemed reluctant to give their own input and opinions. Perhaps they were looking for the "right" answer or were unaccustomed to having the freedom to express their ideas and have these ideas valued. After the group saw that their ideas were essential in order to construct the game, they became more open to contributing their ideas. The interchange between group members and the adult programmer became more interactive. They started to give themselves permission to be in charge. As Oldfather, Bonds and Bray (1994) point out, "We feel more strongly about giving children freedom and time for self-expression, and to let them experience what Oldfather (1993; Oldfather & McLaughlin,

1993) describes as 'sharing the ownership of knowing'. Children experience a greater sense of agency as they find that knowledge is not solely the domain of teachers or other adults, but that they can think, they can know they can experience, as Duckworth (1987) suggests, 'the having of wonderful ideas' " (p.12).

At times, the empowerment of the students created an internal struggle over values between the adults as programmers and the students as designers. The girls who designed the "Magic Carpet" game envisioned the prince saving the princess from the castle. They were asked to reconsider their vision of "who saves who," by asking if they thought about having the roles reversed - the princess saving the prince. The unanimous response was "No, that wouldn't be romantic." These students demonstrated definite ideas about gender roles and romance.

While we doubt that anyone will argue against helping whales avoid being caught in a fishing boat's net ("Ocean Exploration"), we wonder how many adults will object to the demonic tone of "Maze of the Minotaur." For example, in this game there is a devil-like monster that is "awakened" when the player strays off of the maze path. There is also a demonic voice that plays when the player is sent to the "dungeon." Interestingly, a boy was able to create this sound by recording his own voice and then replaying it back at 50% normal speed - a creative technique he learned on his own. In "Space Race" one needs to avoid the roaming "alien," thus giving in to the stereotype that "beings" not like us are to be feared and not trusted. The message is clearly "kill first and ask questions later," not unlike how the U.S. government treated Native Americans in the 19th century. One of the most interesting dilemmas occurred in the design of "Underwater Sea Quest" over the validity of the content. The content calls for a gravity-free, frictionless environment and ocean water does not meet these conditions. The children wanted to keep the context, and in our group discussions we compromised by having this game take place in a "special" ocean in which there was no friction or gravity. **(See footnote[1])**

Undoubtedly, many will find other objectionable elements in the games or game elements that conflict with their values. But because the students were the designers, and our role was that of consultants/ programmers, they retained control of the game's content (even when our values conflicted with theirs).

Conclusions

As previously mentioned, the project has been carried out within the typical constraints of a public school. Most notably these included limited time and limited availability of computer hardware and software. Despite these limitations, the project has provided convincing evidence to support the hypothesis that children, can, in fact, undertake complex design projects such as these when given appropriate support. Not only have the children proven to be capable designers, they have been willing and able to work collaboratively in groups that include their peers and adults. The students have shown the ability to grow intellectually and emotionally in this process. The students recognize when they and their ideas are being taken seriously by their friends and adults. Mutual respect is one result. While the project has not been easy to manage at times, we are slowly identifying obstacles and ways to overcome them. The design phases discussed here, the support tools generated thus far (e.g. HyperStudio Game Design Stack), and the inevitable improvement expected in authoring tools all suggest that computer game design is a learning environment worth considering. Games, electronic and otherwise, are a significant part of the children's lives and social interactions - to engage children in the topic of computer games and their design in a classroom is asking children about something they know a lot about and to show that their ideas carry value and worth.

An obvious criticism of the project has been the reliance on university personnel to program the games based on the children's design ideas and the game objects that they constructed (i.e. graphics, directions, rules, etc.). It was never our intention to suggest that the project is at a stage to be readily implemented by teachers who do not have this support. Other projects, such as that conducted by those at the Media Laboratory at the Massachusetts Institute of Technology (Harel, 1990; Kafai, 1994), have worked with schools who have dedicated large blocks of time to have students learn programming sufficiently to program their own games. We did not have this luxury, working instead with schools interested in the project to supplement, not supplant, the regular curriculum.

While the children who have participated in the project thus far could not have programmed the games to the degree we were able (at least not in the time allotted), this does not mean that other approaches should not be considered. The long history of children programming with Logo shows that children are more adept and more able to handle cognitive tasks than adults first suspect. Although we support the idea of children assuming more of the authoring/programming and giving them powerful computing tools, the real problem we foresee is time. Most schools are simply either not willing or able to dedicate the large blocks of time necessary to have children learn authoring tools sufficiently to program computer games. But authoring tools change quickly. Many of the multimedia authoring tools currently in use in many schools - HyperStudio, Digital Chisel, MicroWorlds Project Builder (i.e. Logo) - enable the design process much more effectively than the tools available even just ten years ago. We expect the next generation of authoring tools to be even more compatible with the interactive demands of computer gaming. For example, Cocoa (http://cocoa.apple.com/cocoa/home.html) (previously known as KidSim) is one tool currently available from Claris Corporation specifically meant for children to design rule-based programs such as simulations and games.

Even at this early stage, there are many practical aspects of the project that can be readily implemented by creative teachers open to constructionist principles. One idea is to have high school students already enrolled in multimedia design classes, common in many districts, collaborate with elementary and middle school classes. The high school students would handle the programming just as the university personnel did in this project. (If these campuses are not located near each other, making it difficult to collaborate in person, web-based approaches to collaborative design might be explored.) Of course, game design does not have to be limited to the computer. Teachers may find their classes eager to engage in building games using the technology of paper, cardboard, markers, and glue. We admit, though, that much of the authenticity of this project has come from the children's desire to be part of the "inner culture" of computer games.

Finally, others will be wondering about other outcomes not mentioned here, such as whether or not the students learned more about math, science, history, language, or Greek mythology. While this is a reasonable question, it is a fairly uninteresting one given the state of the project. Play involves long-term consequences to learning and are not well evaluated on short-term measures (Glickman, 1984; Singer, 1995). However, we anticipate that the next stages of the project will begin investigating such questions. For now, the project has demonstrated that game design gives children an authentic, meaningful context to apply ideas from school subjects - they find designing a game to be a good use of the curriculum and it is a process that make sense to them. Likewise, the project has given us insights as to how children perceive and value school subjects.

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Footnote[1]. Actually, the superfluidity of liquid helium seems to match these characteristics (based on the work of the late physicist and Nobel laureate Richard Feynman; see Gleick, 1992), so perhaps there is a precedent after all for such a "water world."

Footnote[2]. We never learned the full story about this boy or how he eventually became part of the team. We assumed that the teacher had a role in determining which team he joined.

Author Note

We thank the students and faculty at County Line Elementary School, Winder, Georgia and Benton Elementary School, Nicholson, Georgia for cooperating with us on this project. We especially thank the cooperating teachers - Cindy Ellington, Holly Ward, and Amy Halley.

Game Designer Stack (HyperStudio)

This stack was used to help manage the project. Each student had their own copy.

[Download "Game Designer Stack" (Macintosh only) to your hard drive]

Platform: Macintosh
Application needed: HyperStudio (or HyperStudio player).
Size (uncompressed): 99K

[Project KID DESIGNER]

last updated 10/2/98

Project KID DESIGNER

The Games!

Click on any of the screen snapshots below to play the game.

To play the following games, you must have the correct Shockwave for Authorware plug-in properly installed for your browser (either Netscape Navigator or Internet Explorer). The games were designed to work best on Macintosh Computers, but should work also on Windows computers.

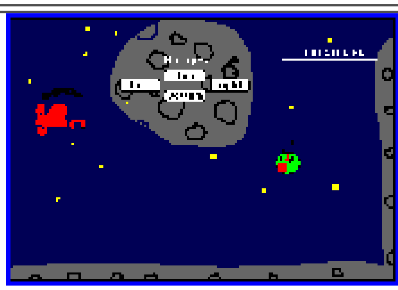
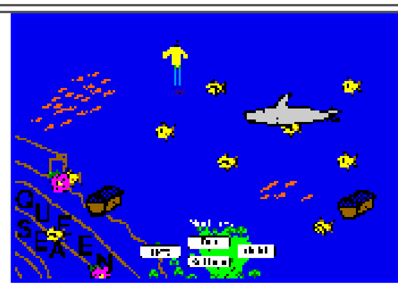
Click here to get Get Shockwave free of charge from Macromedia.

(Be sure to get 'Shockwave - the works".)

Click here if you prefer instead to download all the games to your Macintosh Computer.

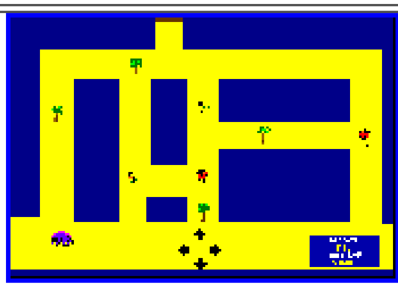
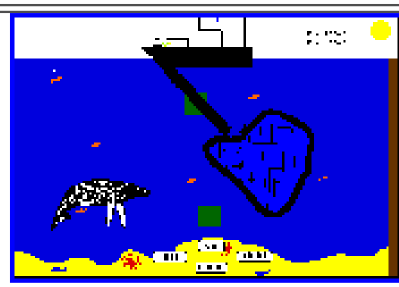
Class 1

Game Topic: Laws of Motion

	
Space Race	Underwater Sea Quest

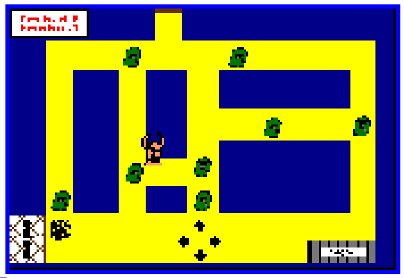
Class 2

Game Topic: Understanding Plants

	
Herb I. Vore's Maze	Ocean Exploration

Class 3

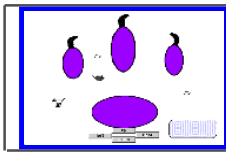
Topic: Mathematics, Language, Greek Mythology



Maze of the Minotaur

Class 4

Topic: See each game below

			
SuperCross	Cat's Revenge	Magic Carpet	Columbus Travels through Time
Math Facts	Math Facts	Math Facts	History

Space Race

Learn about Newton's laws of motion by driving a space rig.

Click here to run the shocked version of Space Race

Underwater Seaquest

Learn about Newton's laws of motion by trying to find treasure while swimming in a special ocean where there is no friction or gravity.

Click here to run the shocked version of Underwater Seaquest

Ocean Exploration

Learn all about plants by helping a whale stay clear of a fishing boat.

Click here to run the shocked version of Ocean Exploration

Herb I. Vore's Maze

Learn all about plants by helping a herbivore eat plants as you go through a maze.

Click here to run the shocked version of Herb I. Vore's Maze

Maze of the Minotaur

Learn math facts, Greek mythology, and answer riddles as you move your Greek hero through the Minotaur's maze. Be careful - don't awaken the monster.

Click here to run the shocked version of Maze of the Minotaur

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Super Cross

Learn your math facts by riding a motorcyle over three different motorcross courses.

Click here to run the shocked version of Super Cross

Magic Carpet

Ride a magic carpet in a beautiful castle to save the Princess while answering math facts.

Click here to run the shocked version of Magic Carpet

The Cat's Revenge

Feed your cat by chasing mice (and a rat) while answering math facts.

Click here to run the shocked version of The Cat's Revenge

Columbus Travels through Time

Help Christopher Columbus and his crew get to the 20th century. Watch out for rocks and whales!

Click here to run the shocked version of Columbus Travels through Time

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Downloading all the games to your computer

Instead of playing each individual game in shocked form, you can instead download a folder containing all of the games to your computer's hard drive. All of these games are copyrighted, but permission is given to all elementary and middle school students and teachers to download these games free of charge. These versions are only compatible with Macintosh computers.

To expand these files you will need Stuffit Expander, Stuffit Lite, or Stuffit Deluxe. Shareware versions of these utilities can be found at Aladdin Systems, Inc.

Click here to download the Project KID DESIGNER games

Platform: Macintosh
Size (uncompressed): 7.8 MB

Project KID DESIGNER

Learning with and about Technology: A Middle School Nature Area

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The President's Committee of Advisors on Science and Technology recently issued the Report to the President on the Use of Technology to Strengthen K-12 Education in the United States (1997). One of their primary recommendations was to:

> Focus on learning with technology, not about technology. Although both are worthy of attention, it is important to distinguish between technology as a subject area and the use of technology to facilitate learning about any subject area. While computer-related skills will unquestionably be quite important in the twenty-first century, and while such skills are clearly best taught through the actual use of computers, it is important that technology be integrated throughout the K-12 curriculum, and not simply used to impart technology-related knowledge and skills (p. 7).

A Northern California Middle School with an extraordinary ecology program represents a case example of the value of learning both with and about technology.

The Peterson Middle School Nature Area

In Peterson Middle School, a 1.8 acre science Nature Area was constructed to facilitate the understanding and appreciation of biological and environmental concerns. Veteran teacher Bryan Osborne supervised an effort that has spanned 2 decades. Beginning with a flat field, the school constructed hills, dug ponds, cultivated plants, and designed eight biological communities to demonstrate a broad range of biological and ecological principles operating in the world: Grassland, pond, swamp, redwood forest, riparian community, deciduous forest, portions of a chaparral community, and a bog.

This is a picture[1] of Bryan Osborne introducing visiting middle school students to the Nature Area. Students learn about Nature Area rules before being permitted to explore and examine the eco-system.

The Nature Area provides fertile ground for exploration, discovery, and experimentation. For example, a 13 1/2 foot deep pond (an inland depression containing standing water) provides many environmental conditions to study in its major biological zones: littoral zone (shallow waters around the edge of the pond); limnetic zone (open water around the center of the pond); and the benthic zone (at the bottom of the pond). Students learn that light, temperature, and oxygen are three of the most important variables influencing the type of life in each zone in the pond community. Sunlight can reach the bottom of the littoral zone, supporting rooted plants and filamentous algaes that create an environment conducive to other life such as damselflies and dragonflies, backswimmers, and diving beetles. In contrast, sunlight rarely reaches the bottom of the pond where flatworms live.

This picture captures Bryan Osborne teaching middle school students about the pond.

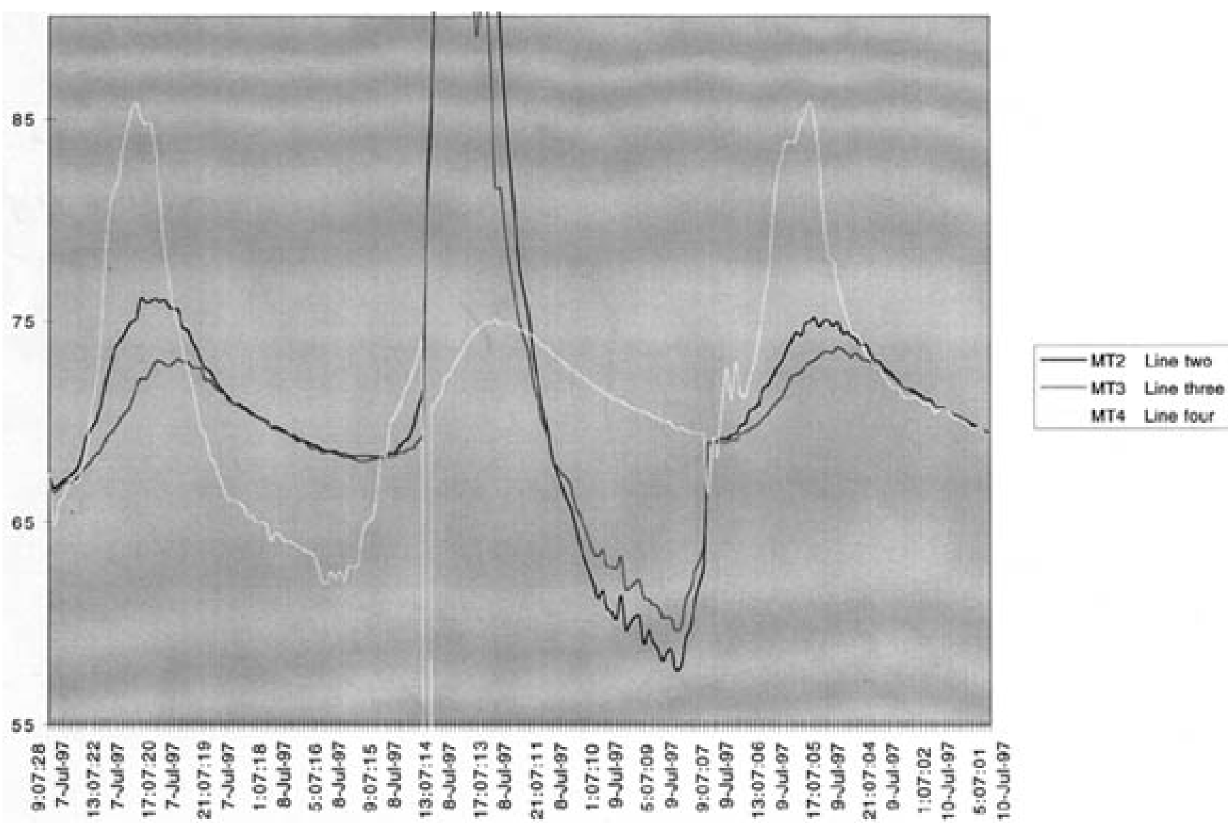
The swamp (a lowland region saturated with water) represents a significant ecological step between the pond and forest. Students study the dominant vegetation of reeds, grasses, and cattails, observe the algae in the open water around the reeds, and watch the snails feed on these plants, and the birds and fish feed on the snails. They learn that an entire food cycle is dependent on the variable state of the swamp water.

This is a picture of the swamp in the Nature Area. Bryan Osborne's son Jacob is skimming excess pond scum off of the surface of the water.

Several research activities focus on the 3 1/2 feet deep swamp. Because shallow water conditions are rapidly affected by changes in temperature, swamp temperatures (largely generated by the presence or absence of sunlight) are monitored throughout the year. Swamp water warms up rapidly with direct sun xposure. Conversely, swamp water cools quickly at night, in the absence of direct sunlight. The warmer the water the less oxygen it can retain; the colder the water, the more oxygen it maintains. Aquatic animals need oxygen. If the temperature of the swamp is too high and the oxygen too low, the turtles, snakes, salamanders, toads, and frogs migrate to the pond. Students come to understand that temperature changes have implications for the ecology of the entire Nature Area.

Swamp Temperature

At the Middle School, the temperature of the swamp is automatically measured and recorded six times a day and stored in the school's computer laboratory. The Nature Area primarily relies on the use of resistive temperature devices (RTDs) attached to a wooden plank and fastened to the dock. The RTD probes hang in the water from the plank. Traditional thermometers are useful to cross-check unusual readings. Temperature readings are recorded at three levels, ranging from the surface to approximately one foot deep. In addition to the raw data of temperature readings, charts of the rise and fall of swamp temperatures each day are generated. Technology plays a role not only in monitoring and studying swamp temperature, but in communicating these research data to the entire middle school community, the district, and the world.



This is a chart depicting the rise and fall of the Nature Areas swamp water surface temperatures. The temperature range is provided on the left side of the chart and the date and time on the bottom of the chart. MT4 is the surface reading, MT2 is a 6 inch deep reading, and MT3 is a 12 inch deep temperature reading. (The sharp rise and dip at 13:07:14 on July 8, 1997 identifies the moment the temperature sensors were vandalized; helping to identify the individuals responsible.)

File Sharing and the Internet

Web pages describe the Nature Area using text and pictures. They are easily updated and disseminated over the Internet.

This is a computer screen snapshot of the Peterson Middle School Nature Area home page at: http://www.peterson.scu.k12.ca.us/~bosborne/

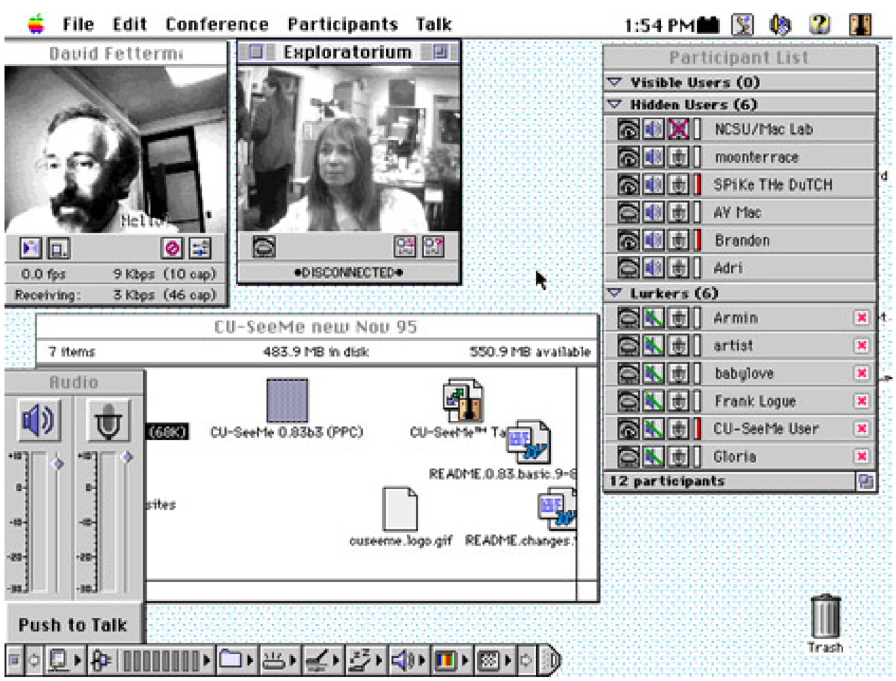
In addition, Farallon's Timbuktu Pro, a file sharing tool, is used to share this data in real time. This software is currently installed in the school's computer laboratory where students work, the remote site (within the Nature Area), and the system operator's home. It enables a teacher to view the chart of swamp water surface temperature from across campus or even from home at any time (without the need to secure access to the computer facility).

Farallon's free but limited capability Netscape plug-in called Look@Me complements the use of Timbuktu Pro (see http://www.farallon.com/). It allows computer users to view each other's desktop but without the ability to manipulate files or exchang e programs. This limitation was an advantage in terms of control in this situation. In the process of locating and viewing web pages and using the Netscape Look@Me plug-in to gain access to this data, students acquire new computer skills and come to und erstand the value of computers in the study of science. This plug-in will allow any computer user in the school, district, or in the world (free of charge) an opportunity to observe and collect relevant ecological and biological data; as long as they hav e access to the Internet. The free Netscape plug-in has been downloaded (and placed in the Netscape plug-in folder) on machines in the Middle School's computer laboratory (which is where most students work), other parts of the district, and at Stanford U niversity to facilitate communication and access. (The Nature Area had to negotiate district firewall and bandwidth concerns in order to provide this kind of world-wide access. However, these concerns have been resolved.)

This is a picture of Bryan Osborne and David Fetterman successfully piloting the Look@Me plug-in, in the middle school computer laboratory.

Videoconferencing

The school is currently in the process of experimenting with and implementing another technology: videoconferencing[2]. CU-SeeMe videoconferencing[3], free black and white software from Cornell, is used in the middle school computer laboratory, with p lans to use it much as the Global Schoolhouse uses it to facilitate research k-12 throughout the world. (See http://www.gsn.org/cu/index.html)



This is a computer screen snapshot of a videoconferencing consultation with a colleague from the Exploratorium Museum about the Nature Area.

This tool can enhance scientific exchange among middle school students throughout the world. Other ideas in the works include use of a videocam connection to transmit Nature Area activity in real time over the Internet, like EarthCam (http://www.earthcam.com)[4].

Conclusion

The Nature Area project highlights the importance of learning both with and about technology. Computers and sensors are used to record, chart, and communicate data such as temperature readings and convey their ecological implicati ons for the Nature Area eco-system. The use of file sharing software and experimentation with videoconferencing software are extending the accessibility of this ecological data. This technology facilitates the use of real-time data, which in turn has mo tivated students to learn content. Although students spent time learning and experimenting with the technology, their primary task was learning an important lesson about the world's ecosystems.

Endnotes

[1]All of the pictures in this article were taken with a digital camera. Pictures and snapshots of computer screens were cropped and transformed into jpegs with Adobe PhotoShop.

[2]See also Fetterman, D.M.(1996) Videoconferencing On-Line: Enhancing Communication Over the Internet.

[3]See http://cu-seeme.cornell.edu; see also, http://www-leland.stanford.edu/~davidf/videoconference.html

[4]See also, Bill's Random Camera (http://www.xmission.com:80/~bill/cgi-bin/camera-list.cgi), Live Cam Pictures World Wide (http://www.wsu.edu/~i9248809/anthrop.html), and Peeping Tom (http://www.coolbase.com/peepingtom/index.html).

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Gender and Digital Media in the Context of a Middle School Science Project

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Abstract

The purpose of this online paper is to textually and visually describe how learners become active participants, trying on a range of gendered attitudes, when studying socio-scientific issues and using video, the Internet, and computer media as their tools. The study was conducted at a Vancouver Island school called Bayside Middle School. Researchers and teachers introduced the topic of a local endangered rain forest called Clayoquot Sound as a subject-to-think-with. Over a two year period, two different classrooms explored the issues, visited the site, and built a range of paper and artifacts making extensive use of a variety of media forms. Video and specifically-designed digital video analysis tools were used by the principal researcher of children's thinking as her primary research tools. The results of this digital ethnography of an emerging media culture show that (1) the use of various video-based media support an interdisciplinary approach to learning within the middle school urriculum when integrating science, social studies, and the visual arts; and (2) gender identity in these mediated environments becomes a flexible construct. Both girls and boys use this media-rich project based learning environment for genderflexing-crossing boundaries that were previously marked by our culture as being gender specific. This study shows how girls and boys, when genderflexing, reach beyond the gender stereotypes that once selected or excluded them from certain forms of inquiry. The researcher suggests that these adventures in genderflexing by young people while constructing social and scientific knowledges can lead to a fundamental change in how disciplinary fields will be constructed in the future.

Introduction: The Gender and Science Debates

This paper reports on a two year ethnographic study focusing on gender, science education, and the introduction of networked digital media for learning in middle schools. My purpose is to shed light on various paths that may guide educators, researchers, and parents to think about the possibilities that lie within, around and outside the current boundaries of middle school science and social studies curriculum. I describe young people conducting a socio-scientific investigation of an endangered rain forest called Clayoquot Sound using emerging technologies as tools to (1) extend curricular boundaries and (2) challenge the notion of fixed gender and style preferences. Moreover, throughout this paper, I invite readers to view digital video clips of girls and boys talking about their experiences, adding comments at the web site where these video clips reside. I conclude by recommending that partnerships among young people, teachers, and researchers are formed to build knowledge cultures of inquiry for young people to pursue investigations according to their flexible gender attitudes.

Little research in the current literature on gender and science delves deeply into the thoughts of young people as they begin first to become acquainted with complex science issues and then to become familiar with the connections between existing scientific practices and their lives. Many feminist researchers and writers discuss the paucity of female role models and mentors for young women (Steinem, 1992), the exclusion of women's ways of knowing the world (Gilligan, 1982; Fox-Keller, 1985, 1992; Belenky et. al., 1986), the positive reinforcement that more aggressive young males receive in science classes (Sadker & Sadker, 1989; Stanworth, 1981 as cited in Spender, 1989; Gaskell et. al., 1992), and the fact that science is at best a positivist masculine construct that perpetuates the view of a world of male privilege (Manthorpe, 1982; Harding, 1991; Weiler, 1995). Walkerdine (1989) states that girls are "counted out" in mathematics and science by schooling methods that do not recognize the way they think about things - boys are encouraged to think in divergent ways whereas girls are not. Girls are encouraged to conform to the wishes of their teachers and others in power for approval. In addressing how to solve the hurdles young women encounter in the science classroom, various approaches have been proposed. On the one hand, some theorists say the curriculum should be gender neutral, and on the other hand, others argue that differences between the genders need to be acknowledged so that girls are not counted out. Challenging gender difference, biological determination, or epistemological pluralism (Turkle & Papert, 1990), Bryson and de Castell (1993) argue that a greater emphasis is needed on how gender differences are produced. “What is required is greater emphasis on the ways in which differences are produced through social relations and institutional practices, rather than on how to create, reify, and consolidate differences by liberalizing curricular options or increasing the number of legitimated "ways of knowing" from one to two (p. 65).”

Concurrently, as a result of a provocative gender experiment implemented by a grade three teacher who used her classroom as a setting to explore her own sexist practices, Sutherland (1996) concludes that, “to initiate effective change in gendered classroom practices, the children must be included in and empowered by the process of change; they must be able to both witness and understand the influence society has on them and have a voice in conceiving the form that change may take (p. 66).”

The study I describe in this paper was designed to both change the social practices in which science knowledge is produced in the classroom and to examine constructivist epistemologies of young people while engaged in these activities. Steinem (1992) herself grew to understand more recently that one cannot change social structures without changing the self and the community around self and vice versa. The study involved mostly Grade 7 students from a semi-rural school setting as partners in the process of investigating the socio-scientific issues of an endangered rain forest. (Grade 6 students were involved in the end of each school year; grade 8 in the beginning of the following year.)

The topic was chosen to enable them to relate to this inquiry in a personal and social manner. Girls and boys were encouraged to find out more about the issues surrounding the conflict while teachers and researchers explored their own notions of what was needed to change the science curriculum to make it more invitational to both girls and boys. The study used emerging video technologies as tools to record formal and informal events. Extensive video interviews conducted by both principal researcher and participants added to the rich data base of the study.

My particular involvement throughout the study, as principal investigator, was twofold. I focused on girls' and boys' gendered conceptions about the traditional science curriculum in relation to this particular innovation. And, I reflected upon my own practice and a specifically-designed digital video data analysis tool, Constellations, I designed with my research team and then used in analyzing the data. In short, while I conducted the gender and science study, I also reflected upon and critiqued the tools, techniques, and artifacts of my own methodology, encouraging young people to think critically about my role of recording and describing their stories.

Premise: Learner as Ethnographer

This study is based on the central premise that the learner shares many common roles with the ethnographer. A learner becomes an expert on the culture of the content, decoding and recoding the meanings and making layering interpretations of events as experiences become richer. Encouraging learners to layer their knowledge and view events from various perspectives in much the same way as an ethnographer constructs the thick description, layer upon layer, (Geertz, 1973) is an important element in creating the convivial learning environment for a project-based study. As learners explore a subject they are interested in with tools to shape the representations of their experiences, they pay attention to how texts (print of visual) can be fragmented and put together in ways not conceived of by the original author. They might find out that, as readers, they construct texts as they read them (Bruner, 1986). Meanings become continually questioned as they learn how to shape and reshape their artifacts. Tying emerging media technologies into this kind of learning environment should provide the opportunity to engage students in both a more personal and a collaborative experience, if, indeed, the promise of emerging electronic media as cultural partners is realized. With electronic partners the nature of inquiry becomes personal, connected, and immediate (Papert, 1996). Learners reflect upon their own epistemological preferences, they can not only solve a problem but talk about that problem from their own points of viewing and others.

This premise of learner as ethnographer is one that, I believe, leads learners to ask whose knowledge, whose story, whose privilege is being represented as local and global events are studied. Learning in a constructionist digital environment becomes an integration of learner, media, texts (including the teacher), and content (or message as McLuhan [1962] would ask to consider) into one contiguous overlapping web. Educators, as partners in this community, help young people put together the bits and pieces of their experiences and the experiences of others (whose work the young people engage with in their texts) into meaningful wholes unique to them, layering descriptions of events as personal interpretations are juxtaposed to the interpretations previously constructed as well as to those which are being created by the community of inquiry. One of the obvious benefits of the Internet, for example, is that young people can now "see" that texts have authors and the "facts" presented in their school texts have hidden the constructionist nature of knowledge from them as they were taught the "basics" and "theories" with little opportunity to ask whose theories and for whose purposes.

When we decide to use media technologies as cultural partners in our learning, I believe, our abilities and our attitudes are extended, flexed, one might say. New technologies propose alternative ways for us to explore topics that are not bound by conventions designed for a pencil-and-paper classroom headed by a solitary teacher. With the help of media partners, learners can connect discrete chunks into groupings and design expressive artifacts that communicate their analyses and interpretations of their voyage to others. They can follow paths, navigate data, and put together textured layers of knowledge within their own learning constellations (Goldman-Segall, 1997). Learners can construct configurations that are unique to their points of viewing the world configurations that bring together the various knowledges they have gleaned from others. This includes the life lived in, around, and with texts, art forms, and reproductions created by people whom one may have only met virtually.

How was this premise that learners are like ethnographers using digital media built into the young people's study of Clayoquot Sound and my study of gender and science learning? Most importantly, learners became engaged in studying a subject that was relevant, concrete, and provocative. Studying Clayoquot (Klak-wit) Sound, one of North America's largest temperate rain forests with intact watersheds, as a community of inquiry provided an opportunity for students to build artifacts and theories about a complex socio-scientific study subject. As I will show, and much to my surprise, it also enabled young people to think beyond their gendered identities and try on new approaches, new thinking attitudes. Both girls and boys more fully utilized a relational, tangential, and storytelling style of thinking about and describing their making of representations. Learning became a situated, context-based interaction between the learner, her tools, and the environment as a whole (Brown, Collins, & Duguid, 1989; Lave, 1991, 1993).

Student Population, Site, and Topic of Investigation

The study was conducted at a Vancouver Island school called Bayside Middle School over a two year period. A partnership among teachers, a vice-principal, the Distance Education Learning and Training Branch of the British Columbia Ministry of Education, and MERLin, our lab at the University of British Columbia in Vancouver was put in place and strengthened as the study progressed. Two different grade 7 school classes, one in 1993-1994 and the other in 1994-1995 built a range of paper and multimedia artifacts making extensive use of a variety of media forms. The girls and boys are fairly homogeneous in ethnic background by first appearances. Many young people are white Caucasian, but, of course, have quite a range of ethnic roots when one does not only focus on color of skin. A community of First Nations young people attend the school both as part of the regular school activities and in classes designed to maintain their cultural preferences and history. This state-of-the-art school was built in 1992. The staff and students had just moved into their new environment, which was equipped with computer labs and had computers in many of its classrooms. The school is modern in every respect: open spaces, sun roofs in hallways, and pods (groupings of classrooms) branching off from a central area, the entrance, where the auditorium, gymnasium, and administrative offices are located. The school looks and feels more like a community center with the hustle and bustle of kids in baggy pants and multi-colored hair. A school that holds many of the possibilities for healthy and educationally rewarding activities.

One of Bayside's 1993 innovations was to provide each teacher with a networked computer. By 1996, the teachers in each classroom had access to an Intranet and the Internet. For example, when I call the vice principal from my home in Vancouver and ask him which teachers might like to work with me on a collaborative study of an endangered rain forest, he dashes off an email message to his faculty asking them to get back to him. They do, within the day (or hour). Each pod, consisting of 10 classrooms, has its own Macintosh computer lab (the size of a regular classroom), with one computer for, at most, every two students. These labs are not project-based environments. In these rooms of wall-to-wall computers (color Mac Classics), the students learn how to use HyperCard, ClarisWorks, MS Word, and other software programs. In Joe Grewal's classroom, however, there is an adjoining workroom with several computers and video workstations with enough space for five or six people. Joe's students design their HyperCard projects in this space. Every person in the school has the right to an email account and has had access to the Internet and computer education since 1994.

Certainly, the learning environment was rich enough to study just the emergence of a computer culture. However, the challenge of making learning artifacts that emerged from a topic rich in diversity and controversy seemed like too great an opportunity to miss. What would they learn? How would they see their own learning? How would they describe their experiences? And, most importantly for me, what could I learn about their thinking about scientific investigations that would lead me to understand the role that gender plays. It is obvious to those who have worked with young people at the computer, that when they become engaged in studying a topic that is important to them, they don't only learn how to use a computer. They learn how to think about what they are researching from many perspectives. They connect ideas from various sources and build upon what they already know. The medium, the computer, becomes almost transparent, an extension of the thinking and making processes. Thus, we chose to investigate a topic rich in controversy.

Many of the young people's families are connected with the fishing, logging, and tourism industries or with government officials determining policy about Clayoquot Sound. Being on an island, albeit the size of Israel, connects people to local issues as a self-enclosed eco-system and social system. The topic, being local with global ramifications, has a high degree of relevancy and interest for the young people. Young adolescents tend to be quite concerned about plants and animals, and about the well-being of the planet in general. Indeed, in British Columbia the middle school science curriculum deals in detail with biodiversity, plant and animal life, and natural cyles. As a result, it was quite straight-forward for teachers to get involved in planning the integration of the Clayoquot theme into their teaching plans. Another reason for selecting this topic was that the Sound had also been the scene of extreme political dissent over clear-cut logging practices for over a decade now. During the summer of 1993, newspapers featured the issues surrounding forest practices at Clayoquot Sound daily. Protesters set up blockades on the logging routes, police jailed protesters, loggers continued to clear-cut, local townspeople in Tofino and Ucluelet worried about their livelihood, environmentalists claimed that bio-diversity was at risk, and government leaders considered their coffers while trying to establish a framework for forest practices. In short, the time seemed ripe for this topic, in this place, with this group of teachers and young people.

Methods: Digital Video Ethnography

The method of study to be described has two webbed and highly interactive parts, and therefore, I will weave my method as a research into the fabric of their activities. The first is the method (and the theorizing about the method, the methodology) which I used to study this community, and the second describes the intervention - what the young people did in their projects. However, as we know in ethnographic research, as in life in general, things are not so tidy. What a researcher does spills into the project, affecting situations that then change the researcher's activities. And, what young people do in their study influences how the researcher navigates through the data. In fact, roles change and students become researchers and epistemologists as they study their subject in this kind of learning environment. There were times when I was not quite sure exactly where we were going on our journey, but the wandering seemed to be the fundamentally important part of the project.

In essence, I became part of the culture of the school and used a variety of tools to support my inquiry. For the first part of the study I videotaped the school culture, everything from events in the gymnasium to lunch times in the auditorium. I also videotaped a wide range of their activities while they were conducting their own video-based investigations at Clayoquot Sound and around the school. I also "hung around" with the young people showing them how to shoot video and entering into conversations about their day-to-day lives in the school. On regular occasions, I conducted and videotaped one-on-one interviews with questions that were designed to elicit and provoke ideas about their own thinking. The questions were often responses to what they said, but sometimes I used a list of questions I would construct in advance to see how the various students would respond. Young people were given cameras so they could videotape their investigations. There were a few old video camcorders in the school that they could borrow from the library. I brought another one from MERLin for the Bayside classroom so that spontaneous events could be videotaped when they decided to do so.

I visited the school site approximately twice a month for two or three days a visit using video and textual notations written on my Powerbook; I kept these reflections available with my computer on and files open for teachers, young people, and parents to read. When the data was gathered (and while the data was being gathered), chunks of data were selected that best exemplified the approach used by the young people in designing their projects. This information was digitized and accessible to collaborative data analysis by myself and colleagues. At this stage, I looked for themes to gain a picture of the broader issues. Once these themes had been formed, I re-edited the video and built digital "vignettes" portraying the young people's thinking. My analysis of the video and text data occurred throughout the investigation. Categories were constantly being developed and shifted as opportunities became available and new experiences were being layered.

In MERLin, my team and I designed three multimedia tools. One tool, called "Constellations," is used to analyze digitized video and text data (Goldman-Segall, 1993). This research tool, based on a tool I designed at the MIT Media Lab called Learning Constellations, enabled me to access text, video, graphs, etc., and to browse through databases, collect and combine chunks into clusters, or constellations, and annotate. (This software can be downloaded from the MERLin site). The other tool is a CD-ROM computer program called The Global Forest designed for middle school students in distributed locations to learn from the Bayside young people's studies of Clayoquot Sound. And, the third is Web Constellations, the first server-side, web-based database system designed to enable a community to catalog, describe, and meaningfully organize data accessible on the Web. Learners or researchers in dispersed locations can use Web Constellations to access the same database and collaboratively analyze that set of data. Stars and constellations can be tagged with keywords and researchers can engage in dialog about particular stars and constellations using the annotation discussion system. Recently, a specifically designed version of Web Constellations has been linked to my book, Points of Viewing Children's Thinking: A Digital Ethnographer's Journey for readers to view the video described in the book and add their comments to other readers comments.

Planning meetings with teachers, the vice principal, and my colleagues from the University of Victoria took place in 1992 and 1993; implementation meetings were less formal and occurred throughout the project mainly over email and in and around the regular class schedule. My visits were usually made with a host of other researchers. My research assistant, spent most of his time working with the young people to solve technical problems. However, he also conducted interviews, spent time with the kids on field trips, and suggested many interpretations about how to think about young people's construction of their gender identity.

In their study, the young people investigated issues from as many perspectives as possible and with as many recorded media as available. They conducted school surveys and organized reports. They discussed the science behind concepts (like biodiversity) in class on a semi-regular basis as part of their science classes. Building portfolios about the issues using both primary and secondary sources, they browsed through the data they collected from the Ministry of Forestry, logging companies, environmental groups, WWW servers, and the usual resources in encyclopedias and school textbooks in the library. However, these young people had first-hand experiences from which to draw their understandings. We went on field trips to logging sites and the towns of Tofino and Ucluelet (situated in the heart of Clayoquot Sound). They slept in the only school in Tofino in sleeping bags on the school gym floor and got to meet the local kids playing a basketball game with them. They conducted on-location video interviews with locals and attended special lectures from scientists, environmentalists, and loggers working in Clayoquot Sound. Visitors to the school back in Brentwood Bay provided a range of up-to-date information. Throughout these events, the young people built multimedia representations using HyperStudio as they delved deeper into the web of discourse surrounding the dispute at Clayoquot Sound.

Most interesting to me was that, young people analyzed their video data from interviews and field trips. They were given copies of the videotapes to take home and watch on their VCRs. We asked them to select a few minutes that best conveyed the topic they were focusing on. For example, if they were concerned with animal life in the forest, they were asked to find data on that subject. However, that is not always what they did. The young people chose video that best reflected the highlights of the field trip for them! The scenes of them wading into the low rolling waves at Cox Bay seemed more interesting to them than a lecture on salmon fighting their way up a logged stream. What happened was that the curriculum would be high-jacked, from time to time, by the social events surrounding the project. Instead of forcing the kids back on track, however, the teachers decided to use their paths to make those paths "teachable moments."

Terri-Lynn describes her reaction to this science project, "I really didn't like science until I came into this year's class and we did the Clayoquot Project. This kind of science I really do like. I asked her, "Which aspects of the project so far have you found the most interesting and which the most boring?" She responded, "Well, like, on our field trip, I really like doing hands-on stuff and not just reading and writing; the trip was really fun. I really haven't done anything boring in the Clayoquot Project because I'm doing digitizing, and then the video project, and then we went to Clayoquot Sound and there's really nothing boring about it (p. 219). "

Another favorite event they recorded was the scene they called the "Bear Scare." Jordan, their teacher, told them how bears like to live in the empty spaces that are caused by trees growing on nurse logs.

Then he encouraged a few of the girls to go explore the mossy hole. As they entered and were having their picture taken, he ran around the tree and came into it from behind, growling like a bear. We all screamed in shock. An odd story to be the pinnacle of the year. But, there it is. Young people constructing their icons for describing events. Young people were also shown how to digitize and edit movies on a Power Mac. Four girls seemed to take this task most seriously. They logged all the data onto logging sheets they designed and named specific chunks. Newspaper clipping, photographs from the field trip, and maps were scanned into the computer. Journals were also entered as part of the database. Thus, the study was conducted as a collaborative community of inquiry. We didn't try to find solutions to the Clayoquot Sound dispute. Rather, we examined it and kept it as "an-object-to-think-with," as Papert would say. We turned it around in our hands and on our computer screens, looking for ways to make sense of our experiences with this "object." What we found was that it was our relationship with it, how we turned an object into a subject of interest for us all, that kept our interest levels high. As Terri-Lynn said, at no point did the study become boring for them or for me.

Online Digital Video Case Studies

Throughout this paper, I have presented an argument that both girls and boys used this media-rich project-based learning environment for genderflexing crossing boundaries that were previously marked by our culture as being gender specific. My thesis is that young people, when genderflexing, reach beyond the gender stereotypes that once selected or excluded them from certain forms of inquiry. What lead me to this conclusion? Instead of describing the case studies to readers in text form, I have decided to share the video data that now reside on a website. However, let me introduce a few of the young people from the case studies and invite readers to enter into a community of interpretions. Then, in closing this paper, I will explain how I have reached a theory of genderflexing and why I believe the use of various video-based media support an interdisciplinary approach to learning within the middle school curriculum when integrating science, social studies, and the visual arts.

Mia, a social activist, did not think she was good at science. In fact, she tells me that she "sometimes doesn't understand it." Yet, she has just finished an 40 page report on the issues surrounding forest life. I asked her if she understood it with Clayoquot. She answered, "Yeah, yeah, I understood the science of Clayoquot! And so maybe something in ecology or something. I haven't decided yet. " I asked her,"So that idea has opened up to you as a possibility? She enthusiastically responded, "Yeah, yeah, I think so, because the more knowledge you have about something, the easier it will be to get interested or get into that kind of thing. So, I haven't really thought about [being a scientist], but maybe now I will. (p. 205)

Justin has a similar problem in understanding his own study, "Like, for science I always thought it was kind of like being a chemist and putting some things together and like making different things. But it has to do with nature, big time." (p. 241)

Perhaps my biggest surprise was that the Bayside Middle School boys repeatedly told me how they needed a "hands-on" (or "eyes-together," as Ryan might say), connection to science, just as often as the girls did. These are the in-between years, when boys still talk sensitively in front of adults and their peers. They are willing to engage and immerse themselves. Ross, in a moment of deep emotion tells me and his two classroom buddies, "I think that science, what it does is, teaches you about things. Like, say there's one main person and say they taught me about Sean and I got to know Sean and I'd be his friend and I'd respect him. But if I didn't know him, I might not say "hi" and notice him that much, and respect him. That's the kind of thing with science, it gets all the things that teaches you to be a friend; and friends you respect. (p. 225)

This interview among others turned my head around. I had once thought only girls spoke so relationally about their relationship to what they studied. This interview forced me to look over my video data and question the neat bi-polarity of the genders. Maybe, things are not divided. Maybe gender is a continuum as writers have suggested no clear masculine and feminine dichotomy but rather a range of ways in which we are gendered by choice or by societal coersion. If so, how could I look for patterns in the data that would help explain adolescent thinking in media environments. I revisited the notion of thinking styles. Papert, who had spent time working with Piaget, suggested that stages be rethought using a word that was much used in the late eighties and early nineties-styles. The articles by Turkle and Papert (1991) and my own work (Goldman-Segall, 1991) proposed a theory of epistemological pluralism. Where Turkle and Papert proposed a "hard" vs "soft" thinker model, with an emphasis on the soft as a legitimate way to practice and theorize about science, my work described three children with three styles, not as the only three but as three that I could identifiy: causal/empirical; social/relational; and, narrative. In revisiting these categories in this study, I had to conclude that I could not place Ross, Sean, and Brian in the causal. Nor could I place them as hard thinkers. What I realized was that styles is too strong a word for adolescent thinking. Adolescent thinking is not fixed but moving, flexing, and changing. The adolescents in this study were tried on various roles. Not that they changed from day-to-day. But they were willing to engage in various forms of discourse. The words that match the findings or constructions in this study are thinking attitudes.

I define attitudes, not as psychologists have used the word in any number of studies that start with the phrase "children's attitudes toward," but as indicator of a fluid state of mind, a ballet pose in which the dancer, standing on one leg, places the other behind it, resting on the calf. Attitude, as a pose, leads into the next movement. Thus attitude is a more flexible notion than style, as it brings together both the positionality and the orientation of the dancer. Ross and his friends move from the outside to the intimate. Ross walks out into the waves, lost in the experience, and returns to the shore slightly changed. He says, "Ricki, it's changed me."

Discussion

Ethnography does not often lead to tidy results but rather to doors that are left open by the ethnographer, spaces to walk through, and descriptions that tend to suggest rather than recommend. I have chosen to write up this study quite linearly and without the poetry of the experience for a few reasons. The first is that the purpose of this article is as much to report upon the research as to experiment with the form of writing with access to the video excerpts and tools for annotation. Because this text has links, I have chosen to present the paper in a less dense and more grazing style with clear markers the signposts of empirical studies, theory, population, site, intervention, method, discussion, results, and conclusion. The second reason for this choice is that the book I have recently written contains the detailed descriptions and the framework for digital ethnographic study in general. For this article, my purpose, as stated previously was to textually and visually describe how learners become active participants when studying socio-scientific issues and using media. Have I done this? Let me close this discussion with Nicole's reflection on her experience, "We'd come up to someone who just looked like they had an opinion on something and we'd say, 'We're doing a project for Bayside Middle School and can we ask you a few questions?' And they'd ask what for, and we'd say, 'about Clayoquot Sound. And if you don't know the answers or anything, we'll be editing it, so it's not like you'll have all the bloopers or whatever.'" (p. 211)

Nicole, through this project, becomes aware of the balance of power between filmmaker and those being filmed. She announces that she will not embarrass anyone by making them seem ignorant or foolish. In her seemingly naive comment, "and if you don't know the answers or anything, we'll be editing it," Nicole acknowledges her sensitivity to the process of both videotaping and editing documentary media. Technically, she speaks with ease about how to get analog signals onto the computer by digitizing them and adding titles and fade-aways. Theoretically, she addresses issues such as trust and truth in reporting. However, she not only is concerned with how the video stories will be presented; she also addresses the complexity of distinguishing between "opinions" and "facts." This is a critical issue in making media, especially in these times when our media culture is in transition. The digital world is not only about signals; it heralds an era of consciousness about our psychological parts, which can be reconstituted into new wholes, and a space where the boundaries between opinions and facts, or between advertising and content, may be blurred. These kids, Nicole in particular, got to understand that.

Conclusions

1. Richer Digital Media Fluency

Several girls and a few boys in this study did realize that what they were doing was a scientific endeavor. In the second year of the project (1994-1995), however, the young people used more video, digitized data, and used the WWW. They also visited Clayoquot Sound on an intensive four day field trip. Although this study does not prove that the non-traditional science students are becoming more competent in their perceptions of themselves as young scientists, I am able to indicate that young people, especially girls and some boys, spoke about themselves and about their activities in ways which show that they became more fluent in the use of the media and about the role of media when thinking about complex socio-scientific issues. In the beginning of the project, one young person, when asked "Where is Clayoquot Sound?" answered that Clayoquot Sound was a clacking sound that was "in the air"! By the end of the project, they could converse, write about, and build representations that showed their deep understanding of the issues. Many had changed their opinions and became a bit more flexible in their understanding of the various perspectives, the various points of viewing. By concretizing their experiences around an intellectual theme connected to their lives, young people began to add levels of understanding about fundamental social and scientific principles, as Perkins suggested in 1986. Their comments reflected a moving from pre-judgment to informed opinion that grew (1) with experience of primary and secondary sources, (2) with an opportunity to balance differing points of view, and (3) with the use of diverse expressive modes of representing what is learned.

2. Gender is a Flexible Constuct

Bayside girls and boys spoke differently about their thinking after our collaborative investigation took place; they spoke with authority, sincerity, depth, and maturity. Being partners with teachers and university faculty in a project where they had opportunities to study science as ethnographers might study a culture by becoming participant observers of a socio-scientific issue heightened their level of connection. As Tobias (1994) points out, "working on interesting, compared to neutral, materials may engage deeper cognitive processing, around a wider, more emotional, and more personal associative network, and employ more imagery" (p. 37).

3. Science and Society More Closely Linked in Media-Rich Learning Cultures

The use of advanced technologies seems to aid people's studying the world as a member of that world. It builds an alternative paradigm for doing science one that is personal and collaborative simultaneously, multidisciplinary, and respectful of diverse ways of making meaning from what is observed and understood. This shift may provide girls and boys with opportunities not only to adapt to changes in science and technology but to be the inventors of that cultural change in the making of science by sharing perspectives, a new way of looking at what we thought we knew emerges. As Hammersley and Atkinson so aptly put it, they become "part of the world [they] study" (1983). When a topic is relevant to the lives of young people, then it stands to reason that they will be more willing to engage in the investigation. What makes the study of science meaningful and interesting is when scientific problems are embedded in a relevant topic that they can examine as a web of complex ideas. In short, they see the topic as being integrally tied in with their own understanding of the world and its complexity.

Implications for the Science Curriculum

Should the curriculum change? How can making connections and seeing relationships among seemingly diverse points of view be appreciated as a valid form of scientific inquiry in schools that is distinct from measurement and breaking things apart to understand causal links? How can young people study topics that deeply and personally relate to them so that they can put together themes from emergent groupings of data? Should we stop emphasizing repeatability and generalizability, and devise theories that are grounded in the manner a large number of living things on this planet carry out their activities instead? Obviously, I would say yes. The barrier is not just the will to address these concerns but it is the ability to understand what prevents us from doing this. As we know from those young people who are active in home schooling, a critical aspect of following through on a large project is being able to have the time to work for long periods on one topic. Until we address this "scheduling" problem we are caught in the circle of small tasks that cannot produce in-depth studies.

Science education needs to include a network of human relationships focusing around topics that involves young girls and boys, topics that are broad enough to contain many points of viewing issues so that individual and group concerns can overlap and interrelate. It seems reasonable to pose as Rosser (1990) has suggested that as more young people become engaged in studying science, the way science is currently studied in schools and in our research centers will also change. Moreover, as Harding (1991) suggests, the nature of doing and defining science will change only when we address the questions "whose science?" and "whose knowledge?" Once we have addressed this feminist question about the nature of knowledge, then perhaps we can move to what Harraway (1991) calls "an earth-wide network of connections, "including the ability partially to translate knowledges among very different" and power-differentiated "communities... in order to live in meanings and bodies that have a chance for the future" (p. 187).

Adventures in genderflexing by young people while constructing social and scientific knowledges can lead to a fundamental change in how disciplinary fields are constructed in the future carefully, inclusively, and with awareness of both the thinking young people bring to the science discourse and the social structures within which these practices occur.

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Growing Up Digital: The Rise of the Net Generation

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Author's Note: The contents of this paper and other NetGeneration issues can be discussed on the interactive forums at http://www.growingupdigital.com

The Demographic Revolution Meets the Digital Revolution

For the past three decades the demographic majority of the US, Canada, Australia and New Zealand has been the baby boom. Anyone born between 1946 and 1964 is considered a baby boomer. As they grew older, the baby boomers gained more and more influence over media, business, and government policy. But as they grew older, they did not grow up as quickly as previous generations. There was little reason for boomers who were not from working class or poor backgrounds to grow up. Being young was to be part of something big. In 1955 kids were everywhere. Almost 57 percent of families contained children under the age of 18 and, unlike now, there was a greater likelihood of there being more than one child under each roof.

As adults the majority of baby boom women put off having children until their '30s and '40s. Society has seen other periods of delayed parenting during periods of economic depression, war, and famine, but that wasn't the case with boomers.

There was another force at work when many boomers-specifically middle-and upper-class young people-delayed parenthood. They were prolonging youth. The experience of this generation's youth was one that saw, for the first time, a youth movement, a youth culture and concerns of youth become the dominant cultural, political, and economic force in their societies.

The demographic minorities born in the decades following the baby boom could not challenge the influence of Baby Boom culture. Theirs was a dominance that went unchallenged, until now.

The baby boom has an echo and it's even louder than the original. The Net Generation has arrived. These 88 million children in the US and Canada who are already combining demographic muscle with digital mastery to become a force for social transformation. This is a demographic wave of youth that is also hitting the shores of selected countries along the Pacific Rim and in Northern Europe. These children are at the heart of the new digital media culture. They are a new generation who, in profound and fundamental ways learn, work, play, communicate, shop, and create communities very differently than their parents.

This wave of youth coincides with the digital revolution which is transforming all facets of our society. Together these two factors are producing a generation which is not just a demographic bulge but a wave of social transformation.

Aged 0-20, N-Geners are embracing interactive media such as the Internet, CD-ROM and video games. The New Generation is exceptionally curious, self-reliant, contrarian, smart, focused, able to adapt, high in self-esteem, and has a global orientation. Not only are they, demographically speaking, the greatest challenge to the cultural supremacy of the baby boomers, but technologically speaking, there has been a change in the way children gather, accept and retain information.

Their Media Usage

This change stems from a fundamental preference for interactive media rather than broadcast media.

Nothing reflects this preference more than the decline in television viewing hours. Television audiences are becoming smaller and more discriminating. Today's young television audiences are more than just uppity - one might go so far to say that N-Geners are refusing to be reduced to spectator status. It is not television specifically that is coming under attack, but rather, the nature of broadcast culture itself.

Broadcast technology, like television, is hierarchal. It depends upon a top-down distribution system. Someone somewhere decides what will be broadcast and our role in this is limited to what we choose, or do not choose to watch. There is no different feedback from the viewer to the broadcaster. Nor is there any direct interaction between viewers unless they are sitting on a couch in the same living room. In TV culture, viewers have no real power, except to channel surf.

Where N-Geners do find power is on the Internet because it depends upon a distributed, or shared, delivery system rather than a hierarchal one. This distributed, or shared, power is at the heart of the culture of interaction.

From Broadcast Learning to Interactive Learning

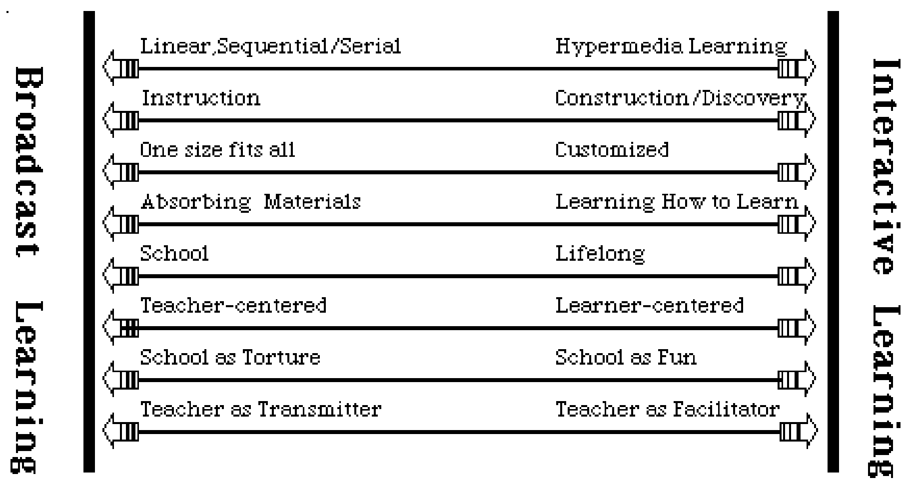
The culture of interaction, if harnessed by schools can be a tremendous force in promoting learning. Computers are an integral part of the culture of integration. Unfortunately, as mentioned above, computers in the schools today are used primarily for teaching basic computer skills, for traditional drill and kill instruction, testing, and for record keeping.[1] The N-Gen experience to date with the digital media points to a new paradigm in learning. The new media enables-and the N-Gen needs for learning demand-a shift from broadcast learning to what I call Interactive Learning.

The Technology of Interactive Learning

In the mid 1970s I was doing graduate work in educational psychology at the University of Alberta and found myself in one of the first classes to take an on-line course. We learned "multivariant" analysis (advanced statistical procedures) using a CAI (Computer Aided Instruction) package called Plato. This course was set up by a visionary in computer-mediated education named Dr. Steve Hunka. We sat down in front of a computer terminal which was connected to a computer-controlled slide display, all connected to a mini computer. (This was before PCs.) The course was fabulous. It took me step-by-step through the material but unlike traditional courses, I could stop and review something I didn't understand or fast forward through material I felt I grasped. I could test myself at various points and the system kept a record for me of how I was doing. Eventually, when I was ready, the system gave me a formal test. The final exam was also conducted on the computer. (And yes, I did actually get an A. In fact, I became so interested in this new technology that Professor Hunka became my thesis supervisor.)

However, because of the cost of such systems, the effort required to create the "courseware" the considerable expertise required to implement them and the huge cultural change in the teaching model, these CAI systems didn't really take off. Today the situation has changed dramatically. There are a wide range of tools and the Net itself, which creates a new paradigm in the delivery of learning.

Figure 1 shows the continuum in learning technologies from broadcast to interactive learning.



The Technologies of Learning-From Broadcast to Interactive

DATA: Alliance for Converging Technologies

Several of the analog technologies are shown. At one extreme is television over which the learner has little control. Watch the show when it's played, from beginning to end. An improvement was videotapes which could be viewed somewhat independent of time and location. For example, the African Virtual University, sponsored by the World Bank, is enabling engineering students to take courses in electrical engineering from a professor at the University of Massachusetts at Amherst. The stateside course is videotaped and transmitted via satellite to participating institutions in Ethiopia, Ghana, Tanzania, Uganda, and Zimbabwe. The professor is available by telephone three times a week to answer questions that the on-site instructor can't answer, or for which clarification is needed. Eventually, the Virtual U will be available in more than forty countries on the African continent.

Books have a greater portability and interactivity than television. They can be scanned and, in the case of texts, you can jump ahead or back. Face-to-face lectures may also have a degree of interactivity as the lecturer can stop, take questions, or even hold a discussion. However, interactivity and discovery are limited because control rests with the presenter and the group rather than the individual learner.

When information becomes bits, the situation changes profoundly. Conventional CAI includes drill programs where the user is presented with facts and then asked to recall them or to perform some operation based on the facts. Tutorials are more elaborate and can cover a broader range of material, as in the case of my statistics course. Games, if appropriate, can provide the learner with a more flexible and creative environment for learning many things from visual-motor skills and rules to the nature of gravity.

CAI programs can improve learning performance by one third-the student gains one year for every three. This is with CAI software programs still being fairly primitive, usually only using text. As the software matures, CAI will become much more interactive and richer, using graphics, audio, and video.

A good example of an interactive text-based CAI program was set up by Ron Owston, professor of education at York University. He designed a hypermedia course for prospective teachers which has two dozen modules. Each module has a topic description and suggested readings with corresponding hot links to the original source. There are also electronic seminars available to each student where the professor participates on more of a peer basis than as the authority who owns all knowledge. Outside experts and facilitators are invited (I was one). There are various assignments, which the students submit on-line and also research tools to help them conduct in-depth investigations of topics and data. The environment also contains information regarding the process of the course, such as schedules, marking systems, etc.

Gabriela Parada, twenty-four, one of the 120 students in the course, raves about the system. "Ron has created an on-line environment which has forced many otherwise on-line-illiterate students to get on-line. I have observed a whole campus of students struggle with the initial technophobia of logging in or setting up connections from home and the significant anxiety that produced. Now these same students are in awe of the potential and powers of technology. Since all of Ron's readings for the course are on the Web, students have quickly learned to navigate so as to find the readings. In the on-line seminar groupings, students must take the knowledge they acquire from the readings on the World Wide Web and then comment and discuss. They are again forced to participate in a virtual community using a messaging system.

"Previous to this course, less than 5 percent of the students at my campus were Internet-literate. This course has opened up a window to the world of technology and many are rethinking its role for their future classrooms."

The new media has helped create a culture for learning, where the learner enjoys enhanced interactivity and connections with others (Papert, 1996). Rather than some professor regurgitating facts and theories to students, they discuss and learn from each other with the teacher as a participant. They construct narratives that make sense out of their own experiences. Various digital forums, such as the ones we organized to research this book, enable brainstorming, debate, the influencing of each other-in other words, social learning.

Owston's course: http://www.edu.yorku.ca/~rowston/found.html

Initial research evidence strongly supports this view. For example, in the fall of 1996, thirty-three students in a social studies course at California State University in Northridge were randomly divided into two groups, one taught in a traditional classroom and the other taught virtually on the Web. The teaching model wasn't changed fundamentally-texts, lectures, and exams were standardized across the two groups. Despite this, the Web-based class scored, on average, 20 percent higher. The Web class had more contact with one another and were more interested in the class work. They also felt that they understood the material better and that they had greater flexibility in how they learned.Such communications environments are enhanced further with the introduction of multiple media. Traditional approaches to learning, both analog and digital, emphasize text and voice. Pictures, such as in comic books, were seen as somehow taking away from learning. But as John Seely Brown of Xerox points out, "if you look at the genre of communication in corporate America, it's actually developing techniques that are quite close to comic books." Understanding this has caused me to change my attitude about my son Alex reading Mad Magazine, for example.

An imminent N-Gen foray into multimedia communications environments is the User Domain. As explained earlier, a MUD is a "place" on the Net where users create their own dramatic adventures in real time. MUDs are evolving into virtual meeting places and learnMUD - Multiing places - virtual social realities - on the Net. Soon your kids studying science will be able to meet in a troubled bio-region and share data, research and solutions. Or to have a meeting in a space station about the results of an experiment on the impact of gravity on viruses.

When you go for a virtual reality ride through the human cardiovascular system at a multimedia theme park, you are experiencing the next step in the evolution of digital learning environments-virtual reality simulation. This began with flight simulation systems which enabled airplane pilots to practice emergency situations, such as loosing engine power, in a safe environment. Virtual reality (VR) today usually involves some kind of clothing such as a glove, goggles, or headset. In special centers the same effect can be experienced with large screens and hydraulics to move the cabin.

The ultimate interactive learning environment will be the Web and the Net as a whole. It increasingly includes the vast repository of human knowledge, tools to manage this knowledge, access to people, and a growing galaxy of services ranging from sandbox environments for preschoolers to virtual laboratories for medical students studying neural psychiatry. Today's baby will tomorrow learn about Michelangelo by walking through the Sistine Chapel, watching him paint, and perhaps stopping for a conversation. Students will stroll on the moon. Petroleum engineers will penetrate the earth to the drill bit. Doctors will navigate through your cardiovascular system. Researchers will browse through a library. Auto designers will sit in the back seat of a car they are designing to see how it feels and examine the external view.As I explained in The Digital Economy, imagine the future applications you might create with

VRML-Virtual Reality Markup Language-the VR equivalent of the Hypertext Markup Language (HTML) used to compose home pages.

Eight Shifts of Interactive Learning

By exploiting the digital media, educators, and students can shift to a new, more powerful and effective learning paradigm. Figure 2 outlines these shifts.

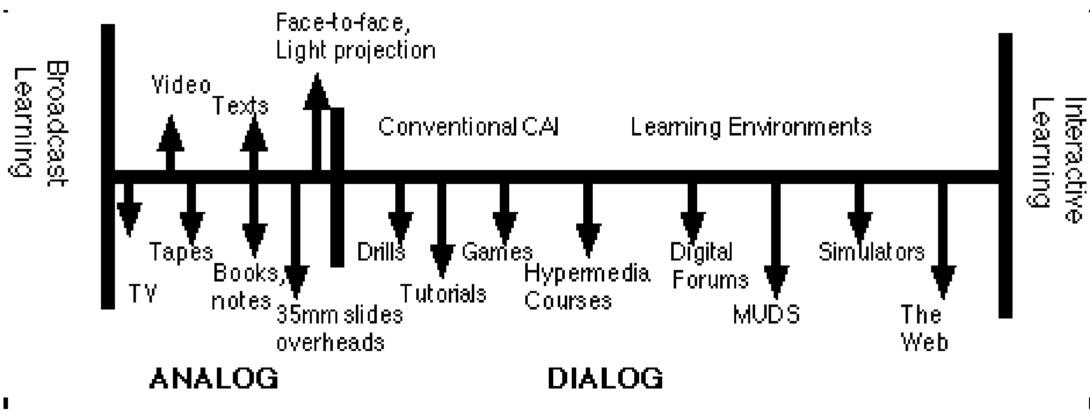


Figure 2: The Shift from Broadcast to Interactive Learning

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1. From linear to hypermedia learning

Traditional approaches to learning are linear. This dates back to the book as a learning tool, which is usually read from beginning to end. Stories, novels, and other narratives are linear. Most textbooks are written to be tackled from the beginning to end. TV shows and instructional videos are designed to be watched from beginning to end.

But N-Gen access to information is more interactive and non-sequential. Notice how a child channel surfs when watching television? I note that my kids go back and forth between various TV shows and video games when they're in the family room. No doubt this will be extended to surfing the Net as our TV becomes a Net appliance.

When we observed our N-Gen sample surfing the Net, they typically participated in several activities at once. When surfing some new material, they hyperlinked to servers and information sources all over the place. Seven-year-old Robert Huang and his sister Franny, eleven, came to our office to show us how they surf the Net. Robert looked up the movie Independence Day, and followed links to fans' pages and returned to the search engine. Interestingly, Robert entered three different searches, but he never went more than two pages away from the Independence Day site. If a download took too long or a page disappointed him, he hit the back key to return to the site.

Franny was a little more focused. Her pet hamster Bupsie was pregnant and she wanted to see sites about baby hamsters. After conducting a Yahooligans search, she followed several links to other hamster owners pages. She traced the mouse over the length until she found a link to an on-line journal which, with text and photographs, traced the development of a baby hamster from its blind and hairless infancy to adulthood-a process that takes only a few weeks. Franny intentionally avoided a Guinea pig link on one hamster page because, "I don't like Guinea pigs, but some people in South America eat them and even I don't want to see a fried one."

2. From instruction to construction and discovery

Seymour Papert says, "The scandal of education is that every time you teach something, you deprive a child of the pleasure and benefit of discovery (Papert, p. 68)."

At the risk of sounding equally heretical, there is a shift away from pedagogy-the art, science, and profession of teaching-to the creation of learning partnerships and learning cultures. The schools can become a place to learn, rather than a place to teach. According to Seely Brown, "Pedagogy had to do with optimizing the transmission of the information. What we now find is that kids don't want optimized, pre-digested information. They want to learn by doing-where they synthesize their own understanding-usually based on trying things out." Learning becomes experiential.

This is not to say that learning environments or even curricula should not be designed. They can, however, be designed in partnership with the learners or by the learners themselves.

This approach is described by educators as the constructivist approach. Rather than assimilating the knowledge broadcast by an instructor, the learner constructs knowledge anew. Constructionism argues that people learn best by doing rather than simply being told; constructionism as opposed to instructionism. The evidence for constructionism is persuasive, but shouldn't be too surprising. The a youngster has for a fact or concept they "discovered" on their own is much more likely to be meaningful and retained than the same fact simply written out on the teacher's blackboard .

Seymour Papert illustrates the difference in his lucid book The Connected Family. He explains that an instructionist might make a game to teach the multiplication tables. A constructionist presents students with the challenge of inventing and creating the game.

Computers today are used to teach mathematics using the drill and kill narrative. "How dull that is!" says Coco Conn. "That's why we never learn math, because it's all about math." She describes the Cityspace project where children from multiple locations collaborate to construct virtual cities, right down to the streets, buildings, and rooms in the buildings. "In projects such as this, you're dealing with a lot of math because the kids are sitting there thinking about the scaling of the model, how many polygons they can put in their object-all about thinking spatially, and mathematically. They are doing it in a way that's fun and also relevant to something that they are creating." She explains that when the project was demonstrated in a four-day workshop, "We had the math teachers tell everyone what the kids were doing with math, and everyone was astounded," she adds.

3. From teacher-centered to learner-centered education

The new media enables centering of the learning experience on the individual rather than on the transmitter. Further, it is clear that learner-centered education improves the child's motivation to learn. Learning and entertainment can then converge.

It is important to realize that shifting from teacher-centered to learner-centered education does not suggest the teacher is suddenly playing a less important role. A teacher is equally critical and valued in the learner-centered context, and is essential for creating and structuring the learning experience. Much of this depends on the subject; no one would suggest, for example, that the best way to learn the piano is the discovery mode.

In the past, education has tended to focus on the teacher, not the student. This is especially true in post-secondary education where the specific interests and background of the teacher strongly influences the content. Much of the activity in the classroom involves the teacher speaking and the student listening.As evidence of this teacher-centered approach, "You'll never find a classroom that spends the first week where the teacher actually learns about their students-what their skills are, what computers they have at home, what games they play, what they're good at, and have the kids share their talent with the whole classroom," notes Coco Conn."So right from the beginning of the year there is little respect for the skills that children have." The new media provides a vehicle to center the learning process more on the student.

Learner-centered education begins with an evaluation of the abilities, learning style, social context, and other important factors of the student that affect learning. It would extensively use software programs which can structure and tailor the learning experience for the child. It would be more active, with students discussing, debating, researching, and collaborating on projects.

4. From absorbing material to learning how to navigate and how to learn

This includes learning how to synthesize, not just analyze. N-Geners assess and analyze facts-a formidable and ever-present challenge in a data galaxy of easily accessible information sources. But more important, they synthesize. They engage with information sources and other people on the Net and then build or construct higher level structures and mental images.

"In our generation, we reach for the manuals-if we don't know how to do something, we ask," says Seely Brown. "We don't engage directly with the unknown and then do sense-making afterwards. Kids today engage and synthesize. Our generation is good at the analysis of things, as opposed to the synthesis of things."

Educom is a consortium of universities and colleges dedicated to the transformation of higher education through information technology. Carol Twigg, Educom vice president, notes how the knowledge explosion has an impact on the curriculum in post-secondary education. She notes the cliche is that by the time a student studying to become an engineer graduates, half of his knowledge is already obsolete: "To use your broadcast metaphor, the professor says 'Here is your curriculum, I will broadcast it at you,

you will somehow absorb it and then move on and be prepared for life.' This is literally a joke." She says we can no longer prepare students to live in a world of rapid change by "shoveling" knowledge at them. "No one has yet come to grips with this whole concept of learning how to learn. No one is doing that in a full curricular sense."

5. From school to lifelong learning

For the young boomers looking forward to the world of work, life was divided into the period when you learned and the period when you did. You went to school and maybe university and learned a competency-trade or profession-and for the rest of your life your challenge was simply to "keep up" with developments in your field. But things changed. Today many boomers can expect to reinvent their knowledge base constantly. Learning has become a continuous, lifelong process. The N-Gen is entering a world of lifelong learning from day one, and unlike the schools of the boomers, today's educational system can anticipate this.

Richard Soderberg of the National Technological University puts it well: "People mistakenly think that once they've graduated from university they are good for the next decade-when they're really good for the next ten seconds." This is a reflection of the knowledge explosion in which the knowledge base of humanity is now doubling annually.

6. From one-size-fits-all to customized learning.

Mass education was a product of the industrial economy. It came along with mass production, mass marketing, and the mass media. Businesses everywhere are shifting to what I described in The Digital Economy as a molecular or individualized approach. We have markets of one where a soccer club is treated as a market, composed of individuals. There are production runs of one-highly customized-from bread to newspapers. We customize products with our own knowledge.

Schooling, says Howard Gardner of the Harvard Graduate School of Education, is a mass production idea. "You teach the same thing to students, in the same way and assess them all in the same way." Pedagogy is based on the questionable idea that "Optimal Learning Experiences," as John Seely Brown describes it, can be constructed for groups of learners at the same age level. In this view, a curriculum is developed based on pre-digested information and structured for optimal transmission. If it was well structured and interesting, then large proportions of students at any given grade level would "tune in" and be able to absorb the information.

The digital media enables students to be treated as individuals-to have highly customized learning experiences based on their background, individual talents, age level, cognitive style, interpersonal preferences, and so-on.

As Papert puts it: "What I see as the real contribution of digital media to education is a flexibility that could allow every individual to discover their own personal paths to learning. This will make it possible for the dream of every progressive educator to come true: In the learning environment of the future, every learner will be 'special.'".

In fact, Papert believes that the one-age classroom-fits-all model "community of learning" shared by students and teachers: "Socialization is not best done by segregating children into classrooms with kids of the same age. The computer is a medium in which what you make lends itself to be modified and shared. When kids get together on a project, there is abundant discussion; they show it to other kids, other kids want to see it, kids learn to share knowledge with other people much more than in the classroom (Papert, 1997)."

7. From learning as torture as learning as fun.

Maybe torture is an exaggeration, but for many kids class it is not exactly the highlight of their day. Some educators have decried the fact that a generation schooled on Sesame Street expects to be entertained at school-to enjoy the learning experience. They argue that the learning and entertainment should be clearly separated. As Neil Postman says, ". . .Sesame Street does not encourage children to love school or anything about school. It teaches them to love television (p. 144)."

But doesn't that say more about today's schools-which are not exactly exciting places for many students-than it does about the integration of learning and entertainment? I'm convinced that one of the design goals of the New School should be to make learning fun! Learning math should be an enjoyable, challenging, and, yes, entertaining activity just like learning a video game is. And it can be! Besides, Sesame Street let the entertainment horse out of the barn. So did video games, the Web, FreeZone, MaMaMedia, and a thousand others.

It is said, however, that if learning is fun it can't be challenging. Wrong! Try getting through the seven levels of Crash Bandicoot or FIFA soccer on your kids video game if you think entertainment and challenge are opposites. The challenge provides much of the entertainment value and vice versa.

Why shouldn't learning be entertaining? Webster's Ninth College Dictionary gives the third and fourth definition of the verb "to entertain" as "to keep, hold, or maintain in the mind," and "to receive and take into consideration." In other words, entertainment has always been a profound part of the learning process and teachers have, throughout history, been asked to convince their students to entertain ideas. From this perspective, the best teachers were the entertainers. Using the new media, the learner becomes the entertainer and in doing so builds enjoyment, motivation, and responsibility for learning.

8. From the teacher as transmitter to the teacher as facilitator.

Learning is becoming a social activity, facilitated by a new generation of educators.

The topic is salt-water fish. The teacher divides the grade 6 class into teams, asking each to prepare a presentation on a fish of their choice covering the topics of history, breathing, propulsion, reproduction, diet, predators, and "cool facts." The students have access to the Web and are allowed to use any resources they want. Questions should be addressed to others in their team or to others in the class, not the teacher.

Two weeks later Melissa's group is up first. They have created a shark project home page with hot links for each of the topics. The presentation is projected onto a screen at the front of the class as the girls talk.

They have video clips of different types of sharks and also a clip from Jacques Cousteau discussing the shark as an endangered species. They then go live to Aquarius-an underwater Web site located off the Florida keys. The class can ask questions of the Aquarius staff but most inquiries are directed at the project team. One of the big discussions is about the dangers posed by sharks versus the dangers to sharks posed by humans.

The class decides to hold an on-line forum on this and invite kids from their sister classes in other countries to participate. The team invites the classes to browse through their project at any time, from any location as it will be "up" for the rest of the school year. In fact the team decides that they are going to maintain the site adding new links and fresh information throughout the year. It becomes a living project. Other learners from other countries find the shark home page helpful in their projects and built links to it. The team had to resource the information, tools, and materials they needed.

The teacher acts as a resource and consultant to the teams. He is also a youth worker-as one of the students was having considerable problems at home and was not motivated to participate in his team. Although the teacher can't solve such problems, he takes them into account and also refers the student to the guidance counselor. The teacher also facilitates the learning process, among other things participating as a technical consultant on the new media. He learns much from Melissa's group who actually know more about sharks than he does (his background is art and literature, not science.) The teacher doesn't compete with Jacques Cousteau, but rather is supported by him.

This scenario is not science fiction. It is currently occurring in advanced schools in several countries. The teacher is not an instructional transmitter. She is a facilitator to social learning whereby learners construct their own knowledge. They will remember what they learned about sharks as the topic now interests them. More important they have acquired collaborative, research, analytical, presentation, and resourcing skills. With the assistance of a "teacher" they are constructing knowledge and their world.

Needless to say, a whole generation of teachers needs to learn new tools, new approaches, and new skills. This will be a challenge-not just because of resistance to change by some teachers-but given the current atmosphere of cutbacks, low teacher morale, lack of time due to the pressures of increased workloads, and reduced retraining budgets.

Footnote

[1]A study of 1,001 teachers conducted by Jostens Learning Corp and the American Association of School Administrators found that while 94 percent of teachers and school superintendents believe computers have improved teaching and learning, they are most frequently used for "teaching computer skills, classroon instruction and record keeping."

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Urgent Emerging Issues Related to Technology Applications in Schools

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Consider the following disparate information bites. How are they related?

- The need for new classrooms has reached an all time high. Over a quarter million laptops were stolen last year - a record.
- The President of the Association of College and Research Libraries reports that it is not uncommon for an Internet user to generate 10,000 hits in response to a query.
- "Computers get better, while prices get lower" trumpeted the caption of a recent newspaper article.
- Researchers at IBM have developed a computer encryption formula, which they believe will be impossible to crack.
- A California school boasted that it has a computer on each student's desk.

Introduction

The preceding assertions are linked in some way to urgent emerging issues concerning the deployment of computer technologies in the schools. They provide a springboard for dialog concerning the technology policies and practices that should guide our schools into the 21st century.

Over the past decade there has been a steady drumbeat for equal access to computers across gender and ethnic lines. This is an important but well publicized concern. Consequently, I will defer considerations of it, and turn instead to several other urgent issues that are of more recent vintage. These issues, all relating to technology applications in school still emerging and amorphous, and have not been fully aired.

The issues under considerations have been lumped into five broad categories, which I will discuss in turn: ethical concerns in technology use, Internet usage, First Amendment and privacy rights, personnel shortages, the ascendancy of the technology critics. This brief essay aims only to outline each of the issues with a broad brush and stimulate further dialog.

Ethical Concerns in Technology Usage

Shortly after the Apple IIe was introduced into schools, it reports surfaced that students were stealing CPUs, thanks to the ease with which these components could be accessed and removed. The contemporary counterpart of techno-thefts appears to be lap top computers. They can be easily slipped into a bag or a knapsack (as the advertising for Apple's new e-mate trumpets).

Evidence suggests that pilferage of tangible computer goods is a common problem for schools. No one is sure how great it really is, and statistics are hard to come by. What seems certain is that the problem will be exacerbated as computers and peripherals are down-sized and freed of their cable tethers through wireless connections. Improved security and accountability measures will help somewhat to prevent thefts of hardware.

Software theft, which deprives authors and publishers of their legitimate fees, however, remains an intractable problem. Software theft also has become an international problem of alarming proportions that threatens trade relations with countries such as Russia and China.

Anti-copying schemes and related measures are likely to remain only marginally effective in combating thefts of software. The greater need is for a new generation of computer users with well-grounded ethical standards that address the unique issues attendant to technology usage. These standards should emerge from moral dialogs that are embedded in realistic settings. The dialogs should focus on topics such as the nature of property, justice and fairness, and what are the right and wrong ways to use technology. Students of all ages should be drawn into these moral dialogs. Piaget (1965) and Kohlberg (1984), among others, provide guidelines for structuring such discussions and for stage-appropriate subject matter.

A more subtle related ethical issue, the attribution of ownership of telecommunications, has surfaced with the explosion of websites, URLs, and email addresses. The canons for citations of authorship and the standards of plagiarism in the print media are relatively well established us well. Regarding recognition of sources and proprietary material from the WOW email, policies and procedures are still in their formative stage.

Teachers should model ethical behavior by always acknowledging authorship and how to ferret it out for information accessed online or offline. At the same time, the attribution issue cuts both ways. There is a mushrooming body of data that has no clearly identified author. Often authors, caught up in the spontaneity and informality of uploading and downloading information, neglect to provide the necessary information to gain credit for their work or even indicate their URL. In other cases, authors choose to be anonymous. Still other documents are a melange of "borrowed" documents with not single author. These cases not only challenge adeqaute attribution, but also make assessment of information quality much more difficult.

Copyright and Cyberspace
[http://www2.ncsu.edu/ncsu/cep/2/clt/workshops/cyberlaw/copyright.html]

Internet Usage

As awesome as the Internet has proven to be, it presents special problems for students. These relate to overcrowding, reliability of information, and acquisition of prerequisite skills.

As students and teachers will attest, for those who must use a modem and conventional wiring to access the WWW, the procession of busy signals often is unbearable. Once connected, the problem shifts to crashes and slow response times from popular sites. Downloading a file during peak hours can be excruciatingly slow. Remote sites with long distance dial-up costs can be another impediment. In sum, planning a lesson around these constraints can be a challenge or even an impossibility, depending on the time of day and the resources available.

Another practical considerations with Internet usage relates to the nature of the output. Not all search engines were created alike. Some casual research revealed that there are upwards of 12 search engines in use, with more in the pipeline. Each claims some special feature that makes it unique. Paradoxically, the more successful they become in distinguishing themselves, the more they confound users who must reconcile discrepancies.

What neophyte users often are unaware of is that the scope of search engine domains differs and is uneven. Hence, the quantity and type of information they serve up in response to a search query varies widely. For example, querying Yahoo, which has the largest datebase, for information about a new drug, Mirapex, produces different results than those generated by the search engine, Deja News. In recognition of these problems, a new class of search engines promises to perform a search of searches (e.g., WebCrawler).

Thorough searches also require prerequisite skills, the foremost being some understanding of Boolean logic. Single advertising is rapidly proliferating over the WWW; students need to be guided in critically analyzing claims. These can be difficult measures to grasp for young children. These issues will command the thoughtful attention of teachers, if activities are to be developmentally appropriate and students are to maximize the benefits of the computer interactions.

A different, more serious problem for students working with the Internet is the quality control issue. Much of what is available online over the Internet is of high quality. this includes primary source data, whether text, video, or audio, and opinions and anecdotes clearly identified as such.

There is, however, another vast and growing unreliable body of data available through the Web. Unfortunately, it exists unfiltered side-by-side with reliable data. Miller (1997), President of the Association of College and Research libraries skewered the problem tersely and dramatically: "Much of what purports to be serious information is simply junk-neither current, objective, nor trustworthy" (p. A44). This phenomenon troubles many educators. Miller cites cases where a single query produced upwards of 10,000 hits. How to separate the wheat from the chaff?

Apart from the Internet issues we have explored, there is the "free lunch" syndrome. Stories abound of the outstanding materials available free through the WWW. The largest from individuals form around the world in contributing without charge an incredible assortment of sights, sounds, and texts is a wonder to behold. Further there seems to be no end to the procession of new data or novel ways to use the data. Without question, however, the free lunches are likely to diminish and even disappear in the coming years. When this occurs, it will require schools to budget resources and look more critically at what the marketplace offers through the WWW.

First Amendment and Privacy Rights

Problems attendant to freedom of speech issues are unique to democratic countries. Arab nations and China, for example, simply established control points that screen connections on the Internet (Noam, 1997). However, freedom of speech issues in a democratic society such as ours are thorny. Witness a recent case in point, the Supreme Court's ruling that the Communications Decency Act of 1996 was unconstitutional. Against the backdrop of an information society, the Court upheld First Amendment rights of free speech. In doing so, it acknowledged the supremacy of free speech despite the potential of children accessing indecent or otherwise inappropriate information.

Key controversies in the information age often involve agonizing choices. Centering around competing measures. On the one hand, how can we preserve our First Amendment rights regarding freedom of speech. At the same time, how can we prevent invasion of our privacy and constrain the exhibition of indecent, salacious, and inflammatory materials to children.

The complexity of the issue is greater today than in the pre-WWW because of the ease with which any individual or group can transmit any information around the world. Currently, everyone with a website can parade their wares in front of the world. Further, sophisticated thieves can invade and manipulate our electronic communications and financial transactions seemingly at will. The scope of the invasion is unknown, since individual and corporate victims frequently do not publicize the losses.

Unfortunately, technology alone cannot solve the problem that technology has spawned, advances in encryptology and security notwithstanding. For their part, schools desperately need a viable plan for reconciling conflicting demands of protection and open access. Although a school district and the community in which it resides cannot completely safeguard First Amendment and privacy rights during computer transmissions, there are some steps they can take.

An initial measure should be to develop, publicize, and enforce a policy for school use of the WWW. Some of the measures taken should include installation of software, such as Cyber Patrol, that can block out adult sites. Purveyors of print media, such as librarians, have long struggled with freedom of speech and privacy issues and their insights should be especially helpful in formulating alternatives. The community also should be invited to be a partner in grappling with the establishment of policies.

Legal Issues & Resources
[http://www2.ncsu.edu/ncsu/cep/2/clt/edsites/legal.html]

Access One Middle School's Acceptable Use Policy
[http://www2.ncsu.edu/ncsu/cep/ligon/au.policy.html]

Personnel Shortages

When all the computers, peripherals, software, and new laboratories have been procured and all the sites wired, there remain personnel and maintenance needs, which can be costly. A paramount need for schools is a new generation of technology leaders, part technicians, part teacher educators, and part k - 12 curriculum specialists. In addition, these individuals may be expected to install and maintain a server and home page and to evaluate and recommend hardware and software procurements, often for two platforms. They also must be able to troubleshoot malfunctions, make repairs, provide on-demand technical assistance, supervise chat sessions, and evaluate hardware and software.

Another key role is staff development. There now is general agreement that preservice and inservice teachers and administrators increasingly will require more hand-on technology training. More specifically, such training must occur in contexts similar to those in which they will employ their newly acquired computer skills. Further, educators will require ongoing contextually embedded support if they are to make effective use of technology. Newly created programs such as North Carolina's Technology Assesment Project which requires all preservice teachers to create technology portfolios and pass a technology competency exam are examples of the push for techno-literate classroom teachers.

Needless to say, educators who can handle all these roles currently are in short supply. Where they do exist, they often are swamped with requests for assistance and leadership. Not surprisingly, they report that they are overwhelmed by the demands of their position. Frequently, given their level of technology and leadership skills, they succumb to he sirens of industry.

Though data on their professional background are hard to come by, the scant evidence we have suggests that much of the training these individuals have received has been on the fly and from workshops, national and regional conferences, newsgroups, and self-directed readings. Sadly, teacher education programs have been responsive only to selected dimensions of the needs of technology specialists. Programs are particularly lacking in practicum experiences that afford in-depth, hands-on training that marries theory and practice holistically, much the same way that the traditional student teaching assignment does. Institutions also often support only a single platform in their training and have inconsistent policies regarding updating hardware and software.

Ascendancy of the Technology Critics

The cost of computers continues to decrease at a rate attractive to buyers. At the same time, however, the costs associated with the storage and maintenance of computers are increasing. Moreover, obsolescence is a constant threat for any school that purports to prepare students for technology applications in the workplace. These realities and the massive infusion of computers and the infrastructure they require, already are causing serious financial problems for many school districts. This is especially the case for districts already strapped for basic needs, such as adequate classroom space and additional teachers.

Not surprisingly, this state of affairs has fueled the rise of a vigorous and growing debate. It has engaged technology advocates and critics in a nest of issues centered around a central pragmatic question: What price technology and is it worth it?

Traditionally, computers have been enthusiastically welcomed at the school doors; the more the better being the operative policy. Further, the merits of technology in schools largely have been assumed. The benefits seemed self-evident from observing children busily at work on computers (Papert, 1993). The steady mantra from techno-advocates was clear and forceful: Anecdotal evidence affirmed that students are motivated by computers and that they learn better and even faster than through conventional instructional approaches.

Techno-advocates also pointed to research findings that claim students who have experienced computer-managed instruction do better on virtually all counts than those in conventional classes. At the extreme, gains are claimed across subjects and grade level for a variety of outcomes; these include: more positive attitudes toward learning and the subjects they are studying, less time required to learn lessons, and higher test scores (Baker, Hale, & Gifford, 1997: Owston,1997).

Techno-critics countered that the reality is in fact murkier. They charge that the effects of technology on learning are indeterminate. Critics also question the appropriateness of the measures (meta-analyses) used to buttress claims of positive research on behalf of computer-based instruction. At best, they allege, the results of research have been spotty and qualified. "So far," Cuban (1997) writes, "no researcher can state with confidence that students using computers will clearly enhance their learning or improve their overall test scores" (p.9a). Further, Cuban has charged: "anyone justifying the purchase and use of computers on grounds that all students will learn more, better and faster is lying" (p.9A, Ownston,1997) has similar reservations about arguments from research studies that advance the cause of technology.

The mass media, sniffing a hot story, already have begun to fire broadsides against efforts of schools to promote computer usage. Oppenheimer (1997) is representative of this class of media critics. His targets include President Clinton, whose stated goals are to extend access to computers to all children. Oppenheimer cites costs in the 40 to 100 billion dollar range over the next five years to achieve the President's dream.

Critics who zero in on costs also are fearful that computer and infrastructure expenditures will divert monies from subjects such as art and music. Oppenheimer (1997) , for example, points to cases across the country where schools already have made cuts in non required subjects such as art, music, and physical education to support computer purchases or hiring computer personnel.

In a different vein, some critics have pointed to the anecdotal evidence that excessive computer usage in schools causes physical ailments such as repetitive strain injury. This is a malady reported to be the leading occupational injury in the United States. A reader (Quilter, 1997) of the New York Times related from her classroom observations: "Again and again we see little faces looking up at monitors plopped on top of too-high tables, little bodies squirming in uncomfortable molded plastic chairs and tiny hands clutching mice -all computer uses that can lead to injury."

One area in which techno-advocates and techno-critics are in agreement concerns the improvement of software: The schools need more and better software for the computers they have. Similarly, the advocates and critics concur that both hardware and software developers need to be more attuned to the educational contexts in which their wares must function.

Further, though software developers have been resistant to the idea, they must begin to take their product cues from the world of children and the existing K - 12 curriculum scope and sequence patterns across the states. To date, for example, no publisher seems willing, say, to lay out a software-driven curriculum for an entire second grade social studies program.

Conclusion

Computers have occupied a prominent place in our schools and homes. They are, for example, the only major technology that was pushed from the home and community into the schools. The growing massive infusion of computers and the resources they require, however, has created some newly emerging issues that
require urgent attention. This essay has sketched out five of them in broad strokes into the following categories: ethical issues, freedom of speech concerns, issues related to the f the Internet, personnel shortages, and the growing numbers of those who are critical of school policies and practices concerning computers in the schools.

Of all he issues, the last is the most threatening to those who have championed the cause of technology in service of learning. What the preceding criticisms point to is a need for greater dialogue between advocates and critics of technology and more carefully controlled and better conceptualized research (Kozma, 1994). Advocates also need to reexamine their rationale for more technology in the schools, since they can no longer take public support for granted.

As technology critics continue to move to the forefront and their voices and influence grow stronger, the odds are there will be a backlash against the massive infusion of computers in the schools and the attendant costs. Unless techno-advocates can demonstrate sustained, carefully validated, and significant outcomes from the use of computers, their natural base of support is likely to erode and their allies dwindle.

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Making a Difference

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In Todd Oppenheimer's recent article, "The Computer Delusion," in the July, 1997 issue of Atlantic Monthly, the author questions funding for more technology in schools and finds no "good evidence that most uses of computers significantly improve teaching and learning." He finds no research that indicates technology has made a significant difference in the classroom. He further suggests that the dollars spent on technology in our schools have produced nothing significant in terms of student achievement. He implies that the time spent on computer-assisted instruction is wasted, since students could learn "all the computer skills they need to enter the job force in the course of one summer."

Interesting. As a classroom teacher who routinely uses technology, particularly in the instruction of middle school web-based writing and publishing, I find it hard to believe there is anyone who could fail to see the power of putting a student in front of a word processor. Do we really need research to show us the advantages of using computers to teach writing? This argument brings to mind similar fears and concerns that surround the introduction of any new tool or technique. Do we really need research to justify every tool and component used in the classroom? When does common sense prevail? Personally, I'd like to see the research on pencils. Where are the studies that prove pencils increase student learning? What about overhead projectors? I am not aware of any research that shows the use of overhe= ad projection devices will increase student learning. Consider the OPEC machines that now allow many students to look for library books electronically. Why should we fund these expensive devices when an old-fashioned card catalog would accomplish the same task?

The fact is, there is a multitude of emerging research that clearly shows the direct relationship between improved student achievement and the use of technology. The network of National Regional Education Labs across the country are gathering the research and documenting it for the use of educators. These labs operate in collaboration with the Department of Education's Office of Educational Research and Improvement (OERI). Of special interest is McREL's (Midcontinental Regional Educational Laboratory) link to current studies documenting the Impact of Technology in the classroom. One of the most interesting articles is "A Summary of Current Research and Evaluation Findings on Technology in Education" By John Cradler, of the Far West Laboratory. A hard copy of the recently published Software Publishers Association report on The Effectiveness of Technology in Schools, '90-'97 also cites hundreds of studies and reports which document the positive effect of technology on student learning.

Oppenheimer refers to existing research on the effectiveness of instructional technology as anecdotal and inconclusive. Yet he unintentionally highlights the real heart of the matter: It is essential that skillful teachers are present in the classroom showing students how to use the computers. Well-trained teachers are the key to the effectiveness of any technology in a classroom setting. Although we know children need pencils, we clearly need to have teachers in the classroom who can show the students how to use a pencil in order to get thoughts on paper. It is clear to most educators that pencils are worth the cost, and it is just as obvious that technology is worth the price.

What is becoming even more apparent is the need for effective technology training for teachers. Many of the first efforts at teacher training mistakenly focused on the skills, rather than meaningful content. Jamie McKenzie (1997) refers to the mistake of "skill fixation" in teacher training, which focused on computer skills outside the context of a real classroom. Teachers were taught how to use spreadsheets, databases, or html without a plan for how or where these skills might enhance their classroom practices. Of course teachers need to learn how to operate the machines and software, but more importantly, they need to learn effective methods for incorporating technology into their classroom setting.

When teachers use technology to enhance their teaching, the results can be powerful.

In MidLink Magazine, teacher editors from all over the world are making meaning for their students out of the vast resources on the World Wide Web.

- Students share book reports with their peers across the oceans.
- Japanese teacher Shiramizu Kenji shares Haiku poetry with American students in the Haiku Exchange.
- Students in an international virtual classroom collaborate with real scientists onboard NOAA research ship Malcolm Baldridge which sailed around the world gathering scientific data.
- Captain Craig Nelson actually visited
- MidLink editors to discuss an upcoming teleconference.
- Students construct three dimensional models in the "Web-O-Lution" project where they share cultures in 3-D with schools in Grodno, Belarus, and Honolulu, Hawaii.
- Children all over the world share their dreams virtually in the spirit of Dr. Martin Luther King in Frada Boxer's "I Have a Dream, TOO!" project.
- They share role models in the Character Counts section where students can describe their local heroes.

Is there any doubt that these students have reached a new level of learning? As I watch the students in my own classroom at Ligon Middle School interact with their peers in distant lands, I do not need research to confirm that what we are doing involves higher order thinking skills, addresses a variety of learning styles and ability levels, and makes learning more meaningful. I see it in the eyes of my students. I see it when they stay after school or sneak in at lunch time to work on a project. I see it when they bring their parents in after school to see their work on the computer. I see it in their e-mail messages to me asking my advice on their tasks. I also see it in the eyes of visitors who come into my classroom expecting to see a teacher in a traditional role with desks in neat rows and quietly attentive students. What they find instead is a teeming, interactive group of students working together to complete authentic tasks. And as for me? They're lucky if they can find me! I'm usually sitting with groups of students working on a problem or crawling around under a table trying to plug in an annoying stray cable. People from the surrounding business community have assured me they can hardly wait to hire these students. I know my students will be ready for the challenges of the job market of the next century because we use the same tools used in the business world: well-equipped computers.

We operate out of an old building in an inner city magnet school. Because of a visionary principal, grant funds sought by Wake County Public Schools, support from NC State University, and some innovative teachers, we are fortunate to have connectivity, software, and talented instructors who take advantage of these resources. Instead of seeking more research to document the effectiveness of technology, I believe we need to be finding ways to make this type of environment a reality for every child in every school in America. Equitable access to technology, and to teachers who know how to use it, can make the difference for children in the rural areas and inner city schools where resources are scarce. Simply putting computers in schools and wiring them up is not the answer.

Linda Roberts, Director of the U.S. Department of Education's Office of Educational Technology, agrees that technology is not a "quick-fix" for what is wrong with today's schools. She points out that research exists which shows that student achievement improves when good teaching is combined with technology. In Roberts' interview on WWW4Teachers, Dr. Roberts encourages skeptics to look at student portfolios, rather than accepting the narrow view of standardized test scores. I believe this is a view that makes sense. Oppenheimer may have unintentionally made the best case of all for the value of a talented teacher who knows how to use technology within the context of a classroom. Of course the act of simply putting computers into classrooms cannot increase test scores! The only way to do that is to get at the heart of the matter and make teachers and teacher training the focal point of our best efforts to improve
education for every student in America.

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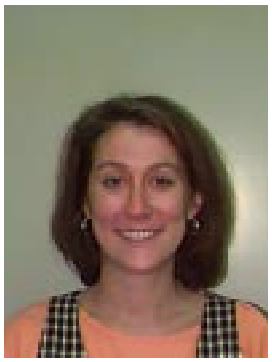

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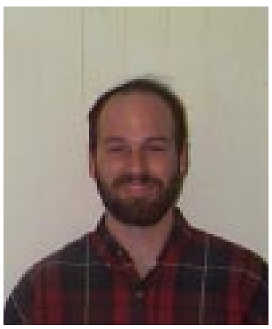

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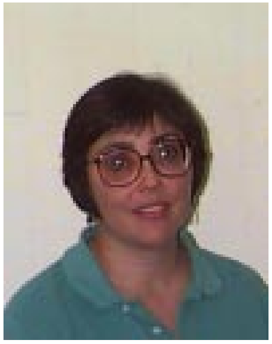

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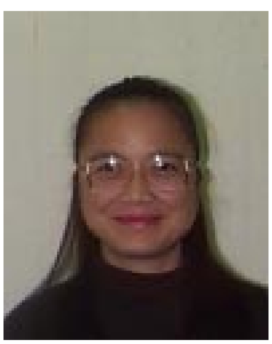

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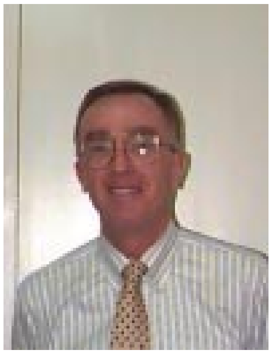

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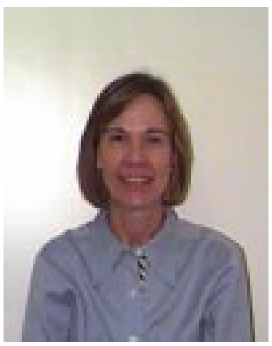

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MERIDIAN

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Editor's Note

Dr. Edwin R. Gerler, Ed.D. • Cheryl L. Mason, Ph.D. candidate

The Electronic Meridian in Middle School Education

On September 15, 1851 some people living near Geneva, Switzerland saw five suns in the sky. They were stricken with fright at this extraordinary spectacle and they believed that the sun was reproducing itself in order to destroy the earth and human existence with fire. What these people actually witnessed was an optical phenomenon created by light striking ice crystals in the atmosphere (Heuer, 1978).

The process of integrating computer and networking technology into K-12 education has often seemed as mysterious and elusive as "light striking ice crystals in the atmosphere." The goal of this new on-line publication, Meridian: A Middle School Computer Technologies Journal, is to introduce educators to the reality and possibilities of applying the latest technology to teaching and learning in the middle school classroom.

A perspective on the multimodal base of middle school education

Middle school education is, above all, a process of promoting growth and development in young adolescents, preparing them for the intellectual, emotional and social challenges of late adolescence and early adulthood. Middle schools incorporate interdisciplinary, broad spectrum educational processes that are enriched by the application of computer and networking technologies.

Many researchers have argued persuasively that educational interventions intended to foster both rapid and enduring development in students need to be broad spectrum in nature, what Lazarus (1981) has termed multimodal interventions. In other words, success in middle school education depends on deliberately influencing a variety of domains that are essential aspects of human functioning. Lazarus has identified these domains as behavior, affect, sensation, imagery, cognition, interpersonal relations, and diet and physiology; he used the convenient acronym "BASIC I.D." to identify the domains.

Case studies as well as numerous research projects during the last two decades have shown the multimodal approach to influence variables important to students' learning. Case studies, for instance, demonstrated the positive effects of multimodal interventions on social and emotional development (Keat, 1985), on self-concept (Durbin, 1982), and on performance of various school related tasks (Starr & Raykovityz, 1982). Another case study (Keat, Metzgar, Raykovitz, & McDonald, 1985) showed that multimodal group activities improved school attendance. Controlled studies involving multimodal programs in the classroom yielded positive results in such areas as school attendance (Gerler, 1980), classroom behavior (Anderson, Kinney, & Gerler, 1984), achievement in mathematics and language arts (Gerler, Kinney, & Anderson, 1985), and reducing procrastination (Morse, 1987).

Beginning in the 1980's and continuing into the 1990's, research with the multimodal program "Succeeding in School" (Gerler & Anderson, 1986) demonstrated positive effects on student achievement and on variables related to achievement. Gerler and Anderson's (1986) study of the program with 900 students across North Carolina showed the program to have positive effects on attitude toward school, classroom behavior, and language arts grades. A California study (Lee, 1993) involving more than 200 students yielded significant effects in mathematics achievement. Other research (Gerler, Drew, & Mohr, 1990) showed the program to have positive effects on middle school students' attitudes toward school.

Computer and networking technology assists educators as they develop broad spectrum or multimodal strategies to promote student growth and development in the middle school classroom.
Meridian: A Middle School Computer Technologies Journal will lead the way as teachers, administrators, and other school personnel work to advance middle school education through the integration of technology. This journal will provide practitioners and researchers alike with new perspectives on the application of computer technology.

The interdisciplinary and multimodal base for Meridian

The debut edition of Meridian ushers in a new era of middle school publications. Meridian is unique not only in its intent, but also in the its administrative structure. As such, it contributes to the field in a most significant and critical way.

Meridian's structure is modeled after the interdisciplinary, multimodal structure of the middle school, and not the discipline specific structure of the university. The review board is comprised of a highly talented team of graduate students who represent an array of disciplines. Members of the review board come from a variety of departments across the NC State University campus: Curriculum and Instruction, Mathematics, Science, and Technology Education, Psychology, Computer Science, Graphic Design, and English.

Each member of the team brings with them a voice of expertise and experience. Electronic exchanges and monthly meetings link the members together and provide opportunities to teach one another and learn from one another. These experiences, much like the broad spectrum educational processes in middle schools, have steered Meridian into uncharted territory . Dewey refers to the individual who comes to an unmarked fork in the road experiencing disequilibrium which leads to growth. Meridian's board members have faced the unmarked fork in the road, yet their collaborative efforts have helped them to successfully chart their way. One is reminded of Dewey's classic truism, "Growth depends upon the presence of difficulty to be overcome by the exercise of intelligence."

Despite the rich and diverse backgrounds, there were complex issues that were new for all involved. Issues such as electronic copyright, review procedures, electronic archives, and electronic dissemination placed us all in a state of disequilibrium. These were questions few had asked before. Expertise from individuals across the University. The University's Attorney's Office, the University Library, and major professors all provided unparalleled assistance.

This inaugural edition of Meridian has emerged from the collaborative efforts of graduate students at NC State University and numerous university resources. The success of Meridian, however, is also greatly attributed from the contributing authors who have each written significant pieces that will begin to fill the void in the current literature devoted to middle schools and computer technologies. Moreover, the articles are significant not only in their message, but also in their use of the medium.

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