Multimedia Science Projects: Seven Case Studies

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Abstract

The research reported here began as a staff development project in which teachers of grades 3-11 produced multimedia projects, conducted a similar project in their own classes, and showed their students' projects at a conference.Researchers acted as participant observers, providing technical support as the students carried out their multimedia projects. Research questions focused on attitude toward science and multimedia projects, gender differences in attitude and expertise, and the process of students taking responsibility for their own learning. Data for this qualitative study represented 3 points of view: teachers, students, and research staff. Findings include the following: (a) Students generally preferred this kind of project to a term paper, except in one school, where multimedia was "old hat"; (b) students and teachers reported that students had learned a number of skills besides science and computing, including dependability, organization, interviewing; (c) both girls and boys at all ages appeared to like computers and doing multimedia science projects, and both were active participants and class experts; and (d) eventually most high school students took responsibility for learning and kept commitments to their groups, and many worked beyond the regular classroom hours.*(Keywords: constructivism, gender, multimedia projects, science education.)*

A constellation of beliefs based on both enthusiasm and theory has come to dominate much of the literature on multimedia as a teaching and learning tool. Many educators hope and expect that the use of multimedia in constructivist classrooms will lead to improved student attitudes, motivation, understanding, transfer, equity, and responsibility for one's own learning. Research, however, has been slow in coming, perhaps in part because the methods we have traditionally used are not adequate for measuring or evaluating what we think is really happening in these learning situations.

Many teachers and researchers can thank Fred d'Ignazio(See "The Multimedia Sandbox," his regular column in *The Computing Teacher* and *Learning and Leading with Technology* since 1989) for their enthusiastic belief in multimedia as a set of tools to take a learner anywhere he or she wants to go. In addition, numerous anecdotal reports, a number of them by software and hardware companies, speak of wonderful projects and highly motivated students (e.g., Carangelo,1991; Winston, 1995). At conferences teachers encounter student-produced kiosks, multimedia term papers, and other long-term technology-based projects that appear to have a large impact on students involved. Our own informal observations had also indicated that this kind of project appears to be equally motivating to girls and boys (McGrath, 1990). In this study we take a close look at seven multimedia science projects and examine science attitudes and understanding, student responsibility for learning, and gender equity in terms of both attitude and expertise.

Theoretical Perspective

Three theoretical perspectives lead us to focus on multimedia projects for learners as a means of enhancing student learning, responsibility, and enthusiasm. These are constructivism, learning as design,and multiple intelligences.

Constructivism. Authors of articles about multimedia in education typically consider themselves constructivists and view the paradigm as changing from teacher-centered telling of information to learner-centered constructing of knowledge. Constructivism is an epistemological belief about how we know what we know, a belief that has no necessary connection with what has come to be known as the constructivist classroom or constructivist teaching methods. Indeed, as Jonassen (1995) reminds us, from a philosophical-constructivist point of view it doesn't matter how the classroom experience is arranged because learners construct their own understandings even in a behaviorist classroom.

Nevertheless, a popular and appealing connection is made between the idea that each person constructs understanding from experience and the notion that we could help that construction process along if we set up a cognitively rich learning environment (e.g., Papert, 1980; 1993). Teachers in constructivist classrooms typically promote sustained projects,often with cooperative learning, the building of artifacts, a real audience,and authentic assessment. Indeed, features of what is called the constructivist classroom have come to be part of the National Science Education Standards (National Research Council, 1993, 1996).

Learning as design. In two influential books, Papert's *Mindstorms* (1980) and Perkins' *Knowledge as Design* (1986), the authors discussed, in very different ways, learning as a design process. Papert (1980) was interested in developing tools that children might be able to use to think, explore, solve problems, and construct knowledge, and then letting youngsters loose to work on long-term projects. In Papert's learning environment,teachers help learners by asking questions and guiding them toward concepts they need to progress to the next step on their projects. Perkins (1986) focused on knowledge itself as a design, with a structure, a purpose, model cases,and means of evaluation; he showed in excellent detail how to teach for understanding so as to make clear to learners what the design elements are for the subject being studied. In a third book on this view of learning, *Learning* *to Design, Designing to Learn* (Balestri, Ehrmann & Ferguson,1992), the authors contend that by designing, students learn design skills and, more importantly, come to understand the ideas underlying their design and become strongly engaged in the learning process. The fundamental premise behind designing for learning is that people learn by working with a subject matter. As Perkins (1992) puts it, "Learning is the consequence of thinking" (p. 8).

Related arguments for student design of multimedia artifacts as a means of learning focus on motivation, collaboration, understanding,and the development of cognitive skills. Blumenfeld et al. (1991) make an excellent case for the motivational value of long-term projects in which students design artifacts. Scardamalia and her colleagues (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989; Scardamalia & Bereiter, 1991) discuss how students' joint constructions on a computer network can help develop knowledge-building communities. Lehrer, Erickson and O'Connell (1994) propose that design of hypermedia-based artifacts can "be used to encourage students to think about how to represent an idea, to think about how to link different representations of an idea, and to think about relationships among ideas" (229). Carver, Lehrer, Connell & Erickson (1992) analyze in some detail the cognitive skills involved in designing Hypermedia documents: project management, research, organization and representation, presentation, and reflection.

Multiple Intelligences. Gardner's (1983) theory of multiple intelligences (1983) also supports student creation of multimedia projects. Gardner holds that people have many intelligences, and that schooling typically focuses on only a few of these. The design and construction of multimedia artifacts, however, can draw on many intelligences (e.g., artistic, logical, linguistic, and musical) and can thus serve to exercise a number of skills and involve students with different dominant intelligences.

The Current Study. These theoretical perspectives suggest that a project-based classroom in which students work with a particular subject-matter for a purpose of demonstrating what they have learned to a real audience should help improve (a) the attitude with which students approach their work, (b) the quality of their work, and (c) their sense of ownership for that work. We may expect learners to work hard, enjoy it, develop a sense of pride and purpose in their work. We do not know whether this anticipated involvement and effort will carry over to performance on a standardized test. It is likely that no traditional measure of learning will gauge this sense of responsibility, this serious personal investment, in a multimedia project. But these outcomes should show up in their expressed and observed attitudes and behaviors and in some evidence of developing expertise and leadership.

Research

There is very little research on constructivist (student-constructed) multimedia and hypermedia. Studies have focused on the design skills learned in the process (Carver et al., 1992; Lehrer et al., 1994; Wisnudel, 1994); planning skills, cooperative learning, concept development, and reflective learning (Toomey & Ketterer); motivation (Blumenfeld et al.); and the process of creating a group project among second graders (Reilly, 1992). A good deal of evidence indicates that multimedia compositions are highly motivating, but very little research attention has been focused on understanding the effects of these compositions. Lehrer et al. (1994) looked at the changes in organizational structure of nodes and links after classmate review of a project and found increased elaboration. Spoehr (1993,1994) has been studying the nature of the projects constructed for history by evaluating the conceptual structures reflected in the projects. She has found that student hypermedia authors produce more complex concept maps. There is not much indication in the research of any age differences, classroom and teacher factors, or good evaluation methods other than concept maps. In the current study, we looked at teacher and student reflections on student learning, attitudes toward the project and the process, and for evidence that students made connections among what they were doing in the classroom, in the multimedia projects, and on their field trips.

Research has been fairly silent on the question of how to best set up and run multimedia projects from a teacher's point of view. Nor has it told us what we would like to know about how long it takes to get students to change from the more traditional learning to the active learning we anticipate from a constructivist classroom or even whether this predicted change actually takes place. In this study, we hoped to learn more about that process of change.

There is also not much solid research on the question of whether multimedia construction is a good way to bring about enthusiasm, access, and understanding for learners of different backgrounds, interests, talents, gender, race, or ethnicity. Some data on field dependency lead us to believe that multimedia projects might enhance equity in some fields of study. Research indicates that female, Hispanic, and African-American learners, for example, are often field-dependent learners and that this may be an important reason for their lower achievement in and interest in mathematics and science (Oakes & RAND Corp., 1990; Stiff & Harvey, 1988). According to the Oakes and RAND review, "...because mathematics, science, and technology are taught most often as abstract and disconnected from other people, these subjects are more appealing to white males than to women or minorities" (p. 171). As instruction proceeds over the grade levels, these subjects become more abstract, more divorced from people and community, and more often taught by books than by activities, girls and minorities tend to lose interest, and when they have a chance to do so, drop out. It therefore seems likely that putting computer-based tools in the hands of students and letting them produce multimedia projects on science topics associated with their own region of the state, as we did in the current study, will connect *all* kinds of students to authentic science issues in their own communities, that is, to people, and thus connect them more to science itself.

The Current Study

The context. This study was carried out in the context of a staff-development project funded by an Eisenhower grant for teacher enhancement in science. It was a one-and-one-half year study; the first semester was aimed at secondary teachers, and the second year was a repetition for elementary and middle school teachers. Teachers read about and discussed concepts about enhancement of science teaching from a constructivist point of view and did their own multimedia project. They then developed a plan for a similar project in their own classes, implemented and evaluated the process as students tried it out (with on-site and telephone technical assistance),and finally they assessed the entire experience and presented their projects and observations to a public audience at a conference. Ehrmann & Balestri(1992) suggest that the best way to learn science and other subjects is to set up a design studio in which to work. Their own classrooms were these teachers' design studios.

Within this framework, the researcher and graduate assistants(research staff) wore several hats. We were teachers, guides, coaches, and on-site technical assistants to both teachers and students. We also wanted to study the process of learning multimedia-production skills and constructing multimedia science projects in different kinds of classrooms,and so we were also participant observers in a multisite case study. These sites were at a great distance from our campus, and the grant paid for on-campus training for teachers, two meetings for the secondary teachers, and three visits to each of the seven project classrooms. These limitations will help you understand our methods and observations.

Research questions. The research questions that formed the central focus for this qualitative study formed three clusters:

- **Science understanding and attitudes.** Do teachers and students believe that students learned from this project? Is there evidence that students make connections among ideas and concepts from class, field trips, and project? Do students like doing this kind of science project?
- **Gender and attitude.** Are there gender differences in attitudes toward science or multimedia? Do leaders of both sexes emerge? Do both girls and boys become experts in some aspect of the project, either scientific or technological?
- **Responsibility for learning.** Do students take responsibility for their own learning when doing this kind of project? How do they do this? How long does it take to get them into the new problem-solving independent-learning mode?

Consider this research exploratory, a sort of first step in a "design experiment," if you will (Brown, 1992). In a setting in which teachers are permitted and encouraged to design their own ways of having students create multimedia science projects, with only a few parameters set for them, we expect to learn something about what such classrooms are like, how they function, and what the obstacles are. We can hope to find tentative answers to our research questions and, perhaps, come up with suggestions for teachers who want to try such projects. The next step will be to take these ideas as hypotheses and move them to more tightly controlled situations for a closer look.

Method

Participants

Participants were 10 teachers of grades 3-11 from rural schools in Kansas and their science students. Eight were women and two were men. Classroom sizes varied considerably, from 6 to 24. In three cases, pairs of teachers and their classes worked together on a project; therefore, although we studied 10 teachers, we had only seven case studies.

During the first semester of the research, three of the five teacher participants (Group 1) were high school biology teachers, and the remaining two were a seventh-grade computer and science teachers working on the same project. During the second part of the research,one of the five participants (Group 2) was a middle school computer teacher recruited to teach science, two were a sixth grade science teacher and an eighth grade technology preparation teacher working together, and two were elementary teachers of third and fourth grade working together. All ten had been recruited to be part of a teacher enhancement project.

Student participants were 108 of the students of these 10 teachers. Judging informally from observation only, 105 appeared to be Caucasian, 12 Asian American, 1 African American, and one of East Indian heritage.

Participant Observers

The research staff included the researcher, four doctoral and one master's student, all in the educational computing program and Kansas State University. For each group, the researcher and two graduate students were participant observers. The researcher taught the graduate course and visited each site on the third visit. The graduate students helped the teachers with the technology and then divided the locations so that each had two sites to visit, three times each.

Procedures

Grant and school costs, and teacher enhancement events. As a result of personal contacts with teachers in Group I and advertising by the North Central Kansas Educational Service Center, five secondary and middle school teachers volunteered for the project and had the support of their schools. Schools provided, at a minimum, a Macintosh with a color monitor, at least 4MB RAM, and a VideoSpigot video card; a field trip for the students; and substitute teachers for the six days the participants would need to miss class. The grant paid for teacher travel for workshops and a teachers-only field trip, HyperCard 2.2 (1987-1994) software for each teacher, and tuition for the teachers to receive graduate credit for this combination computer training and curriculum project.

Through contacts from Group I and word of mouth we found five elementary and middle school teachers to participate in Group II, a year-long repetition of the project. The grant did not have enough money left for the third day of the kick-off workshop, the two all-day workshops, the teachers-only field trip, or substitute teachers, but otherwise the process was comparable to the first one. To make up for the lack of support provided by those meetings, the remaining grant money was paid to four of the Group I teachers to act as mentors, advisors, and technical assistants to Group II teachers for 10-20 hours each. This plan was chosen because of the proximity of these four teachers to those in the second group. This second group was given from September to May for training and completion of student projects, because the students were younger on an average, and because the first group of teachers felt that a semester was too pressured for them as they were just becoming familiar with the technology. (See Table 1).

Table 1
Summary of Group I and Group II Schools and Events

Group I, Year I: teachers start in January, students finish in May

high school 1 (HS-1); biology teacher
high school 2 (HS-2); biology teacher
high school 3 (HS-3); biology teacher
middle school 1 (MS-1); science and computer teacher

January: teachers have kick-off multimedia workshop and discuss project
January & February: two additional teacher workshops
March: teachers-only field trip to Cheyenne Bottoms
March-May: students learn HyperCard, do projects, show projects
April: students go on field trip to Cheyenne Bottoms
October: teachers each bring ≥2 students to a national conference held in Kansas, to show their work and talk with conference participants.

Group II, Year II: teachers start in September, students finish in May

middle school 2 (MS-2); teacher mentored by HS-2 teacher 2; ends up using HyperStudio because new class in January - had to start from scratch
middle school 3 (MS-3); science and technology teacher; mentors not consulted
elementary school 1 (ES-1); (third and fourth grade teachers) mentored by HS-1 teacher

September: teachers have kick-off multimedia workshop and discuss project
Fall: students learn HyperCard, in some cases take field trip and start research
Spring: students work on project, complete it in May
Late April: teachers each take student projects to conference to show other science teachers and talk about what went into the projects

Student projects and on site assistance. Group I teachers started the student projects as early as mid-February and as late as mid-April with an introduction to HyperCard (1987-1994). Each set of students collected scientific and other types of data in a nearby natural setting and planned how to put their findings and understandings into a HyperCard stack. Students in Group I took a field trip to Cheyenne Bottoms. Teachers in Group II taught their students to use HyperCard during the fall semester. The three project groups took field trips at varying times during the year, and all three groups produced their projects during the spring semester. With or without input from students, each teacher designed the content and extent of the science to be involved in the project, group assignments, group sizes, assessment criteria, and the length of the project. Major project requirements were that (a) that teachers must get their students outside to make observations, and (b) they must have their students produce a multimedia project about those observations, as a group or in small groups and for a real audience, such as parents, other students, or the school board.

Research staff promised to make at least three visits to each school, one at the beginning of the work with HyperCard (1987-1994), one toward the middle of the project, and one at the end to see the final projects.These visits were to serve two purposes. First we wanted to provide on-site assistance to the teacher when getting started with HyperCard and when student technical questions became more difficult. Second, we were to act as participant observers, ask a lot of questions, and videotape and audiotape classroom activity when possible.

Teacher and student conference presentation. Teachers in Group I were asked to bring at least two students to a national conference on rural schools, which took place at Kansas State University several months after the conclusion of their projects. There they appeared in the exhibit hall where conference participants could see the projects and talk with the students and teachers about their experiences in doing such a project. Research staff, assisted by another graduate student, took this opportunity to interview teachers and students one last time. Group II teachers presented and discussed their students' projects to other teachers at a state conference for science teachers in April, when their students were just finishing their projects.

Types of data collected. Sources of the data used for the following analysis included (a) research staff notes written before,during, and after meetings (these were not extensive field notes, but merely occasional notes to remember events, decisions, or particularly salient events or observations); (b) videotapes of both field trips, one meeting, all school visits, and those made at the first conference; (c) audiotapes from telephone interviews, on site teacher interviews, and the conference; (d) teacher journals; (e) student journals; and (f) the completed projects for each of the seven schools. Two of the graduate students conducted extensive interviews of their own, and their data are part of this report. These data, taken as a whole, represent several points of view: that of teacher participants, their students, and the research staff. We, unfortunately, do not have all sources of data for all project groups because of the nature, extent, and limited funding of this project; the distance of some of the sites; and occasional technical difficulties. (See Table 2).

Table 2
Data Available at Each Site

	HS-1	HS-2	HS-3	MS-1	MS-2	MS-3	ES-1
Student journals	X	X				XX	XX
Teacher journals	X			X	X	XX	XX
Teacherworkshop	X	X	X	X			
Visit #1, video	X	X	X	X	X	X	X
Visit #2, video	X	X	X	X	X	X	X
Visit #3, video	X	X	X	X	**	X	X
Teacher interview (oral or written)	X		X		X		X
Student project	X	X	X	X	X	X	X
Student interview	X(2)	X(2)	X(6)	X(2)*		X(2)	
Field trip teachers (video)	X	X	X	X	(no field trip for Group II teachers)		
Field trip students (video)	X		X	X		X	

Notes. XX means both teachers on the team
(n) refers to the number of people involved
*equipment trouble - hardly any data
**3 visits to this school, but new students started in January, and only 2 visits to the new class

Methods and foci of analysis. Videotapes and audiotapes for Group I were scrutinized by at least two members of the research staff during the fall after the first year of the research had been completed. Several meetings of research staff were held to exchange ideas, observations, and themes, and to give new assignments for review of the videotapes. Data from both Groups I and II were given a final analysis after the end of the second year by the principal investigator, focusing on the three research questions and some unanticipated issues that emerged, such as self-esteem and audience.

Observations

Teachers, Classes, Projects, and Audience

In this section the schools are abbreviated HS, MS, and ES for high, middle, and elementary school. Teachers are abbreviated T1-T10, where T1-T3 are high school teachers, T4-T8 are middle school, and T9-T10 are elementary. T1-T5 were in Group I, and T6-T10 were in Group II.

Problems and frustrations

Not surprisingly, there was a long list of frustrations which occurred because most of the teachers and students were new to HyperCard (1987-1994), and were trying to do a project while they were also learning HyperCard, scanning, and QuickTime (1989-1994). Students for the most part did not complain, but one can see some of the frustrating times on videotape. In HS-2 the students submitted end-of-project reports in which their teacher asked one question about problems they encountered. The list of items named by one or more students included nearly everything technical that could be named (movies,sounds, links, color, beveled buttons, fonts, scanning, digitizing video, sound, etc.).

Again, because they were new to this kind of work for the most part, teachers and students encountered other problems typical of novices, such as saving an old file over a new one, working off a floppy instead of the hard drive, and not taking care of their floppies and losing their data. Equipment problems particularly nagged the elementary school. During the first semester elementary students had to make appointments to use the computer lab at the high school and walk there. This often was not a good solution because high school students were already there working. During second semester, they borrowed two computers, and one of the hard drives crashed. One school's scanner died, and another school's tutorial tapes didn't work. Some didn't have access to a scanner at all.

Two groups, teachers felt, took too long on the project (MS-1 took eight weeks, and MS-3 took an entire school year). In the first case,the computer teacher did not want to spend that much of her time on only one software package; in the second case, teachers felt they had to get their students enthused all over again in the spring. Students in another group felt they had too little time (HS-2 had less than 8 weeks), partly because students had to teach themselves HyperCard (1987-1994) and that took some time.

There were VideoSpigot problems in several places, such as ordering the wrong version, switching to an AV machine midstream and having to learn new software, and never getting the Spigot to work at all. Pictures and movies were usually too big for floppy disks, and most schools did not have anyway of getting data from one computer to another except by floppy. Research staff occasionally loaned out a portable drive.

Rural students have the opportunity to do a wide variety of things because there are so few students available for the various activities. Students have a good chance of being, for example, on the school paper and on the baseball and track teams. Teachers coach drama and football and teach math, science, and English. Everyone is very busy. The downside of this phenomenon is that it is very difficult to hold a class in which all students are present, particularly in the spring. For cooperative learning projects, the drawbacks are obvious. Students can't consult with each other; those that are left get stuck trying to figure things out by themselves and doing other people's work. The two rural high school teachers, in particular, complained that this kind of a project should not be done during track season. T1 had to resort to having her students communicate by notebook about what each had done and what needed to be done.

Teachers in rural areas are also isolated from each other,with typically only one science teacher per school; therefore networks of support become very important. E-mail worked for a couple of the teachers, and that helped. The research staff were very responsive to phone calls, and they got a great many of them. There was a great deal of on-site problem solving involving both teacher and students, all of whom were trying together to learn something new.

Science Understanding and Attitude

Teachers individually decided on their own grading criteria for this project, and there was no independent formal assessment of either knowledge of or attitudes toward science, the main subject of these projects. In no case was this project the *only* science learning going on during the year; the project was one of many learning settings and opportunities provided at all sites. The data that form the basis for the findings reported in this article are student, teacher, and research staff observations, reports, and reflections.

Attitude toward the content of multimedia science projects. High school projects were all interdisciplinary, and students showed a good deal of interest in the intermingling of the science and history connected with their local study sites and in plants and animals. Elementary school children focused on specific animals and habitat, and why people need to be concerned about animal habitats. Their journals reflected a real enthusiasm about the science they were learning.Students of all ages appeared to really like the field trips that were basic to every project.

Attitude toward multimedia projects. Every group except MS-2 (see the Old Hat section later in this article for a description of MS-2) showed a great deal of enthusiasm for using multimedia to do science projects. Reasons given included: "getting to know so much about one place"; learning "so much more"; "not so boring as books," questions, tests, and lectures; "it doesn't seem like science"; "it was hands on"; "it's fun"; and "you don't have to do reports."

Change in attitudes toward science. Students' attitudes toward science did not appear to be influenced by this project. Although they enjoyed this project a lot, they did not claim that it increased the likelihood that they would continue to study science. When asked if this project influenced their liking of science, they typically responded with silence or mumbling. One exception was a group of three students from HS-1, who liked studying the land right outside their school. Two things did appear to make a difference in student attitude toward science: the teacher and the field trips.

Teacher and student reflections on learning and understanding. Students at the high school and elementary levels felt they had learned a lot from this project, and they could tell you what they learned. Students at the middle school level seemed to have more trouble either remembering their field trips or making connections among the various parts of the project(research, multimedia, and field trips). The project had its ups and downs,lasting as long as it did. Teachers at all levels at varying points in the project expressed both frustration (with students' level of work or understanding)and pride (in students' creativity, interest, and hard work).

Teacher observations of skills that are necessary for this kind of project. Both during and after the project, teachers commented in journals and interviews about the kinds of skills they thought students needed for a project like this, and they often expressed surprise that students didn't already have these skills. Skills mentioned were: interviewing, taking notes,finding information, writing, and organizing. Two high school teachers were interviewed at length about their thoughts on student skills, and they gave us the most complete picture of the skills students needed to learn for such a project. One high school teacher described the aesthetics or design skills that need to be developed.

Teacher observations about changes in the quality of student work. High school and middle school teachers and students reported that students learned many other things besides science in this project, and some of their comments suggest the broader learning that took place. Teachers felt that students had begun to learn something about writing, organizing, interviewing, finding information, and even how to deal with dead ends in their research. High school students reported learning such things as "compromising with a work partner," "the value of dedication and hard work," "the challenge of figuring our things" on one's own, "how to create an interesting report," "research and application skills not only for this project, but for future 'optional' critical thinking projects," and dependability.

Gender

In all projects, students worked in groups of two to six , all of whom were usually the same gender. For the most part students chose their own work partners, except in MS-2 and MS-3, where they chose the subject-matter they would work on, thereby determining their partners. Each group was responsible for its own project, or piece of a whole-class project, so all students participated to some extent in all activities,including research, writing, and constructing the multimedia; a notable exception is MS-2, where students divided themselves into three separate groups--computer, art, and research--and never collaborated to put it all together. Three categories of analysis on gender-related issues were examined in this study.

Attitude toward technology-related aspects of project. For the most part, both female and male students spent similar amounts of time doing technology-related activities. Students of both sexes indicated that they enjoyed these tasks: color, beveled buttons, screen transitions, sound,graphics, scanning, videotaping, digitizing video, entering text, working on layout, linking, and entering and editing text. It is apparent from observation, student journals and interviews, and teacher journals and interviews that girls and boys liked these activities equally well. Groups of youngsters, both girls and boys, occasionally reported confusion or boredom; neither feeling seemed to last. For the most part, both girls and boys had a high degree of involvement and investment in all aspects of the project. In the one elementary school, the girls appeared to be dominant.

Attitude toward subject matter. All projects dealt with science, but the first year's projects also involved the history associated with the local wildlife area they were studying. Girls and boys alike expressed or demonstrated an interest in the science and history and the processes involved in learning both (including not only data-gathering, but also note-taking,interviewing, etc.). In Group I and Group II students, both boys and girls were particularly excited by the field trips, and students of both sexes enjoyed the science and learning involved. Because we were unable to detect any change in preference for science as a result of this project, we did not pursue the question of gender differences in attitude change.

nbsp; **Leadership and expertise.** In no case could we find an exception to the statement that both leadership and expertise were equally distributed among the girls and the boys in any of the seven sites. This does not mean that everyone liked and excelled at everything; indeed, there were some notable dislikes and some stereotypical preferences as well. For example, one group of fourth-grade girls never seemed to enjoy themselves because they spent much of their time arguing over who would get to type, and some girls spent a good deal of time investigating color and drawing. But there were nonstereotypical interests as well--girls liking sound, boys being good at creativity in artwork, girls knowing how to put movies in a stack, boys being good at writing, and so on. The possibilities offered by group projects in multimedia meant that there were a great many roles to be filled, and learners of all types stepped into fill them.

Taking Responsibility for Learning

Length of time for the project. The length of time that students worked on the multimedia science projects varied from site to site and among different age groups. High school projects took 8-10 weeks, and middle school projects took 2-6 months. The elementary school project took about 8 months. Teacher and student journals and interviews and the three sets of video observations tell the story of the changes that took place.

Changes. Students began the project with enthusiasm but were unaccustomed to the kind of thinking, planning, organizing, and independent work that the project required. In the Visit 1 videotapes we often see students acting puzzled, and getting students to participate in brainstorming discussions was like pulling teeth. Yet some students were already trying to figure things out among themselves. During Visit 2 we began to see a change from puzzlement to active attempts at inquiry, locating information, collaboration, and problem solving. At the high school level, this change from passive to active, from a sense of being lost to a sense of purpose, appears to begin by about the third week, but is not sufficient to completely finish and polish the final product without a lot of effort from the teacher to prod and guide them. It is more difficult to tell about the change process for the other grade levels because the classrooms and times allotted were so widely different and because the visits were spread out over a greater time.

Responsibility to the group. Typical scenes in every classroom (except MS-1 and MS-2, in which students worked only within their groups) involved collaboration and problem solving in every imaginable permutation--a project team working together; one team (or member) helping or consulting with another team; or problem solving among teachers, students, research staff, and sometimes with other teachers or students from the school. All people involved persisted in the face of many technological frustrations. There are many indications that students felt responsible to their group or class for their part of the project, and sometimes even stepped in to help out with parts of the project that had been assigned to other students.

Sustaining hard work. Students from all of the high schools came in for many extra hours during and after school, on evenings, on Saturdays, and during the summer, whether to do their own part or help others; to work on the natural area to mow, plant, or water the plantings; or to simply go looking for snakes. One boy carried his camcorder with him while he worked in his family's fields so that he'd be ready if he saw any interesting animal life to put in the project. Students from MS-3 were all volunteers; theirs was not a graded project.

Personal investment in the final product. Reports from teachers and students alike indicated a personal investment in what the final product looked like, particularly as the time approached for a public showing to an audience about whom they cared. At the end of the projects, teachers and students seemed to be pleased with their work and relieved that they had successfully completed this enormous project.

Additional Observations

Two additional findings stood out in the observations, interviews, and journals. The first was the striking relationship of self esteem to audience. The second was a surprise, and suggests what we might expect from students who have used multimedia for years.

Self esteem and audience. One time-saving middle school tactic was apparently a means of getting two different classes involved in working together before they began their project. MS-3 teachers had the sixth graders, who had been using HyperCard (1987-1994) for a while, teach the eighth graders who would be part of the same project but had not yet learned HyperCard. This turned out to have a remarkable effect on the self-esteem of the younger students, as commented on by teachers and noted by nearly every sixth grader in a journal entry.

Other instances of increase in self-esteem in this project were reported by several teachers. In some cases the person had some skill that others could learn from. In other cases it was related to the pride everyone experienced from showing their presentations at the end of the year.

Although teachers tried to fulfill the requirement of an audience experience somewhere in the project, it appears that this was in some cases perfunctory. That is, although they cooperated, not all teachers felt that an audience was as important as the researcher did. They did not, for example,tell students ahead of time that there would be an audience and who it would be. As projects were being polished up for whatever audience there would be, students began at the end to be concerned about the quality of the multimedia project, in part because teachers themselves began to feel pressured. For example, second year teachers all showed their students' projects at a conference for science teachers in late April; therefore teachers were particularly anxious that things be in shape for their own (authentic) performances.

Old hat. The experience of MS-2 in which doing multimedia was "old hat" to the students gave us the impression that most of them were not at all interested in it, except for those few (3 out of 24) who happened to prefer working on computers. The teacher was very excited about using multimedia on this project, but students were really quite uninterested. They had done this kind of thing since the third grade.

Discussion and Conclusions

In this study we set out to look for clues about the process of constructing multimedia science projects. We examined student attitudes, the kinds of things students learned, the ways in which the oft-cited"taking responsibility for one's own learning" manifested itself,and whether girls and boys both took leadership roles or developed expertise in these projects. What we found confirms most, but not all, of our hunches and suggests hypotheses and questions for future research.

Learning and Attitudes

Teachers and students believed that a lot of learning took place not only about science and computers, but also (in high school projects) about the many issues associated with studying a place in one's own community, e.g. history, tradition, laws, and resources available for such research (museums, newspapers, etc.). And we began to see the impact these projects made, particularly on the older students, who reported learning to hold up their ends of a group effort, the importance of not waiting until the last minute, the satisfaction that comes from designing something or figuring out something yourself, and the self-esteem found in teaching someone else what you know. Students of all ages tremendously enjoyed this way of learning and worked very hard at it, confirming the Blumenfeld et al. (1991) claim of multimedia's high motivational value. However, student appreciation for science itself was not observed to change as a result of this project, disconfirming the notion that the project's connection to the local community would increase students' connection to the field of science. It appears that for high school students, however, their notions of what constitutes "science" was broadened and they found this interdisciplinary work appealing.

Teachers found that students were surprisingly unprepared to do the kind of research and organizing tasks needed for such a project (see Carver et al., 1992), but noted that these skills did improve as students found a need for and used them. This observation supports a design view of learning because it begins to spell out the processes that are involved in real intellectual work and the learning that takes place during even a first attempt at such a project. One teacher (T1) had given a lot of thought to those aspects of the technology (e.g., fonts, color, etc.) that assisted in representing the subject in multimedia format. The excellence of her students' project lends support to Lehrer et al. (1994), who suggest that such artifacts can be used to help learners think about how to represent an idea. Two of the teachers collaborated on a project at three of the sites, but no teachers collaborated with teachers of art, English, or any other subject in which expression in a new medium could be an explicit subject for students to examine more deeply.

Gender

We chose to examine gender as a factor in attitude and expertise for two reasons: (a) our earlier informal observations had suggested multimedia to be motivating for both girls and boys, and (b) Oakes& RAND (1990) had proposed that science and technology would be more appealing to girls if taught in a way that involves activities and connects learners to people and community. Indeed we found boys and girls equally enthusiastic, equally committed to the project, equally able to demonstrate expertise and leadership, and equally excited about the multimedia aspects of the project. Girls also seemed to like science as much as the boys. However, there as no indications that girls or boys were more likely to continue in science because of these community-based multimedia projects.

Responsibility

Our data lend a great deal of support to the popular claim that multimedia project design increases student responsibility for their own learning. This was seen in the many hours high school students put in outside of their regular school day, the voluntary nature of one middle school project, student persistence after much frustration, sustained work over a long period of time, reports of helping and teaching each other and stepping in to do the work of absent colleagues, concern for how this project would appear to an audience, and reports of feeling that they had to be reliable because others were depending on them. This change in learners was bumpy, with some doing it and some not, some doing it today but not tomorrow, some doing some responsible things but not others, and with great teacher frustration at times. But as the end drew near, students rose to the challenge,and were universally and deservedly proud of their finished products.

The fact of a valued audience turned out to be a very important factor in this process of change from traditional to responsible learner. We might well take a lesson from this observation. Student self-esteem, pride, and visible rewards from amazed audiences were seen when the audience was a peer group or parents. These qualities, based on researchers' own informal impressions, were not observed when the audience was simply the teacher, classmates who were also involved in the project, or the researcher.

Finally, one middle school classroom was unique in a number of respects, one of which was the fact that they had used multimedia for years and were not very interested in using it during this project. They enjoyed the science and the field trips, but very few chose to work on the multimedia part of the project. It may be that when multimedia projects become commonplace, they will lose their holding power. That is, it is conceivable that design is not the issue in these projects, but rather that novelty is the important factor. This is a disturbing possibility, and one we are not enthusiastic about proposing. But the question requires further inquiry, because too many resources are being invested in this direction if we are simply seeing the effects of novelty. There is, however, at least one alternative explanation:the make-up of this particular group of students. These were students who hadn't been successful in science the previous semester, and the hands-on field science course based deeply on field trips was designed specifically for them. This very concrete learning experience was quite appealing to these students, and they either may not have been ready for the design experience or may have found it distracting from other activities that were important to them.

This readiness-for-design hypothesis suggests that we should reexamine some of our data from the point of view of age, as well.Age had not been a targeted research question, nor had it even been a part of the original grant proposal, which was aimed at the secondary level.But we may nevertheless reflect on what we saw. Students at all ages were enthusiastic, involved, and learned the appropriate amount of science and technology for the project. But the sense of responsibility was absent at the elementary level, very mixed (really only seen at MS-3)at the middle school level, and very impressive at the high school level. It seems likely that the design project has elements that can best be developed at the secondary level. This is an important hypothesis to examine, because it is usually the younger students who have the opportunities that a self-contained classroom presents to work with multimedia: time, space, and less emphasis on narrow subject matter.

Recommendations

We offer some tentative recommendations to teachers who are interested in having their students design multimedia projects. You should be encouraged by the enthusiasm and positive attitude shown by girls and boys at all ages (at least if this is a new idea to them). Be aware that students do not come with ready-made design skills, and be prepared to think about these issues aloud with your students. We are confident that these skills won't simply happen. Just as with problem-solving skills (Salomon & Perkins, 1987), if you want to develop design skills in your students, you will need to give them extensive and varied practice and talk about it with them. If students do not know the authoring program ahead of time, you need to be prepared to spend time teaching the technology. However, as MS-3 teachers said, after the first year, students will know how to do it, and probably can and will teach others how to do it. Learning the technology, doing the research, and putting together a polished project will probably take about 6-8 weeks at the high school level and a semester at the middle school level. Don't expect it to be perfect or smooth the first time around. You might consider collaborating with someone in a related subject area, either an expressive area (art,

journalism, or English) or a content area (history, social studies, mathematics). Interdisciplinary projects are recommended. Keep a journal of what worked and what didn't,how long it took, and what events took place when. Do this in the fall, not the spring.
nbsp; Researchers need to follow up on some of the questions raised by this set of case studies. For example, at what age can learners best benefit from design work and what kinds of support do they need? If researchers can locate a community in which project-based activities connected to people and the community take place in science throughout the schooling years, they might also be able to answer the question of whether this kind of work could really make a difference in whether students stick with a subject like science, as Oakes and RAND (1990) contend. These questions suggest the need for longitudinal studies.

On a more short-term basis, research needs to examine the relationship we observed between audience and self esteem. For example,what would be the effects on personal investment in a project of having the students choose the audience and of having them know from the beginning the who, how, and when of the presentation? What might it be like to use formative evaluation techniques or beta testing on a project before presenting it to the valued audience? Another important question is the motivational value of multimedia: Is it simply a novelty effect, or does it remain motivating as learners develop their design skills? There must be a number of communities now in which learners have done this kind of work for a couple of years, and we should study the changes in students as they learn to design.

There are many questions to be answered about the processes and outcomes involved in multimedia design projects. But we are encouraged by this and other early research on constructivist classrooms to continue asking these questions and working with teachers and students. Many of the answers seem likely to come from qualitative research.

References

Balestri, D.P. , Ehrmann, S.C. & Ferguson D.L. (Eds.). (1992). *Learning to design, designing to learn: Using technology to transform the curriculum.*Washington, DC: Taylor & Francis.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M. & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3), 369-398.

Brown, A. (1992) Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *J. Learning Sciences, 2*(2), 141-178.

Carangelo, D. (1991, September). Wiz Kids put magic into Fields of Learning.*Curriculum Product News*, 48-49ff.

Carver, S.M., Lehrer, R., Connell, T. & Erickson, J. (1992). Learning by hypermedia design: Issues of assessment and implementation. *Educational Psychologist, 27*(3), 385-404.

Ehrmann, S.C. & Balestri, D.P. (1992). Learning to design, designing to learn. In Balestri, D.P. , Ehrmann, S.C. & Ferguson D.L. (Eds.). *Learning to design, designing to learn: Using technology to transform the curriculum.*Washington, DC: Taylor & Francis.

Gardner, H. (1983). *Frames of mind.* New York, NY: Basic Books.

HyperCard [Computer software]. (1987-1994). Cupertino, CA: Apple Computer.

Jonassen, D. (1995). *Constructivist Learning environments.* Introduction to Segment 2 of online RESODLAA discussion, and subsequent replies.

Lehrer, R., Erickson, J. & Connell, T. (1994). Learning by designing Hypermedia documents. *Computers in the Schools, 10*(1/2), 227-254.

McGrath, D. (1990, Nov.). *The hypermedia "term paper."* Presented at the KAECT Fall Conference, Manhattan, KS.

National Research Council (1993, July). *National science education standards:July '93 progress report.* Washington, DC: National Research Council.

National Research Council (1996). *National science education standards.*Washington, DC: National Research Council.

Oakes, J. & The RAND Corporation (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education, 16*, 153-222.

Papert, S. (1980). *Mindstorms*. New York, NY: Basic Books.

Papert, S. (1993). *The children's machine.* New York, NY: Basic Books.

Perkins, D. (1986). *Knowledge as design.* Hillsdale, NJ: Erlbaum.

Perkins, D. (1992) *Smart schools.* New York: The Free Press.

QuickTime [Computer software]. (1989-1994). Cupertino, CA: Apple Computer.

Reilly, B. (1992). The negotiations of group authorship among second graders using multimedia composing software. ACOT Report #14. Cupertino, CA: Apple Computer.

Salomon, G. & Perkins, D.N. (1987). Transfer of cognitive skills from programming: What and how? *J. Educ. Comp. Res., 3*(2), 149-169.

Scardamalia, M., Bereiter, C., McLean, R.S., Swallow, J. & Woodruff, E. (1989). Computer-supported intentional learning environments. *J. Educ. Comp. Res., 5*(1), 51-68.

Scardamalia, M. & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media.*J. Learning Sciences, 1*(1), 37-68.

Spoehr, K. T. (1993, April). Profiles of hypermedia authors: How students learn by doing. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Spoehr, K.T. (1994). Enhancing the acquisition of conceptual structures through hypermedia. In K. McGilly (Ed.). *Classroom lessons: Integrating cognitive theory and classroom practice,* 75-101. Cambridge, MA: MIT Press.

Stiff, L. V. & Harvey, W.B. (1988). On the education of Black children in mathematics. *Journal of Black Studies, 19*(2), 190-203.

Toomey, R. & Ketterer, K. (1995). Using multimedia as a cognitive tool.*J. Res. on Comp. in Educ., 27*(4), 472-482.

Winston, M. (1995). The ultimate science lab. In IBM handout, source unknown, p. IBM-6-IBM-8.

Wisnudel, M. (1994). Constructing hypermedia artifacts in math and science classrooms. *J. Comps. in Math. and Sci. Teaching, 113*(1), 5-15.

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