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Building a Community of Designers: Restructuring Learning Through Student Hypermedia Design

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How do we create better learning environments in the classroom? Some researchers advocate restructuring the classroom through student design-based inquiry. This paper reports a year-long classroom study that used student design-based inquiry to reform the classroom toward more constructivist teaching and learning practices. Two teachers in a rural school and their 125 seventh graders attempted to build a classroom community of designers, where students learned a variety of research and communication skills through designing hypermedia documents. Results of initial qualitative analyses show the development of the classroom over the school year (including the new roles for teachers and students) and challenges from the institution of schooling. The paper focuses on the perspective of one of the participating teachers in the study, using data primarily from his journals to illustrate the evolution of instructional practices and student learning throughout the year.

Some attempts to create better learning environments have centered the classroom on student design projects (Brown & Campione, 1994; Carver, Lehrer, Connell, & Erickson, 1992; diSessa, 1992; Harel, 1991; Harel & Papert, 1991; Lehrer, 1993; Lehrer, Erickson, & Connell, 1994; Penner, Giles, Lehrer, & Schauble, 1996, in press; Perkins, 1986; Resnick, Ocko, & Papert, 1988; Williams, Bareiss, & Reiser, 1996). In these environments, students build various artifacts or products. However, the goal is not simply to design a good product; rather, the goal is to reform education, to create better learning environments where students can gain both cognitive skills and domain content. Many of these attempts to restructure traditional learning and instruction are synergistic: They simultaneously change many aspects of the traditional classroom, including the roles of teachers and students, curriculum and assessment, and the place of technology in the classroom (Brown & Campione, 1994). The current study reports a case of two seventh-grade teachers reforming multiple aspects of their classroom environment through student design-based inquiry. This paper focuses on the perspectives of one of the participating teachers, using his words to illustrate the evolution of the classroom over the school year.

Why restructure education through a focus on student design? The metaphor "of design" offers an overriding goal for learning that provides continuity over a sustained period of time, taking students from planning and product development to evaluation and revision (diSessa, 1992; Lehrer, Erickson, & Connell, 1993). Students share ideas about the hypermedia products and how they designed them.[1] The community spends a significant amount of time discussing their designs. This discourse about student design is crucial, as it allows for thinking to be made visible (Albright, 1992; Erickson & Lehrer, in press; Lehrer et al., 1993, 1994). For example, students in these environments are encouraged to articulate ideas for both designs and conceptual understandings in class discussions. This not only assists students in clarifying their own knowledge, but it allows those ideas and understandings to become objects for discussion, as in Papert's (1980, 1992) "objects-to-think-with."

By making design the metaphor of learning and instruction, a teacher can also provide an authentic context of inquiry and discourse in the classroom (Harel & Papert, 1991; Lehrer et al., 1994; Perkins, 1986; Resnick et al., 1988). Constructing something that has a purpose, such as designing hypermedia documents to teach peers about history, contributes an element of authenticity to a task. It provides the motivation, criteria, and justification for students to critique and improve the construction (diSessa, 1992; Lehrer et al., 1993). The community can observe multiple ways of approaching both the process and the designed products, and it can negotiate understandings in a domain. The focus of the classroom becomes not only to learn by designing, but to learn by thinking about one's design, how

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[1] In this study, hypermedia is a way of authoring on the computer that combines text, graphics, sound, and animation.

that compares to other ways of designing and similar products, and how to revise and improve what one has done (Harel & Papert, 1991; Lehrer, 1993).

This paper traces the development of a classroom over 1 school year as teachers attempted to create a community of designers. The teachers used design-based inquiry to restructure the nature of learning and instruction toward constructivist practices. The study involved seventh-grade students designing hypermedia documents to teach peers about topics integrating language arts and social studies. As students and teachers together designed both curriculum and assessments, the classroom became a community of designers in which the teacher was no longer the sole arbiter. Students asked their own research questions, developed their own information, and became each other's teachers, critics, and audience. Students and teachers each had "ownership" over certain forms of expertise, but no one individual had it all (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993). Members of the community had or took responsibility for finding out about needed knowledge. The study decentralized the traditional role of the teacher and distributed instruction, evaluation, and knowledge across the classroom community. This paper provides a rich description of many of the principles at work in the classroom environment, illustrated with exerpts from a participating teacher's journal.

Current Study: Building a Community of Designers

Participants

The study took place in a large rural middle school (n = 720) in the Midwest. Five classes of seventh-grade students (n = 125), 20% of whom were labeled as learning disabled (LD) and mainstreamed into classes, rotated through two subject areas (reading and social studies) each day for 45-minutes each. Students worked on designing hypermedia compositions in one or both of the subjects, anywhere from 2 to 5 days a week at various points throughout the year.

The two teachers in this study "team taught" in that they planned curriculum together and did multiple collaborative projects throughout the school year. However, they taught their classes individually. One teacher had an M.S. degree and had been teaching for 7 years. The other teacher had a Ph.D. in education and had been teaching for 13 years.

[2]Hypermedia projects were not the sole curriculum in these classrooms. The teachers used other curriculum and other design projects such as video documentaries. The school day was divided into 45-minute periods, in which students rotated through various subject areas. However, this study focused on student hypermedia design in the reading and social studies classes.

Instructional Setting

The two teachers in this study had initiated a series of student-designed hypermedia projects throughout the year to promote students' critical thinking skills and their understanding of the reading and social studies domains.[2] Instruction for the projects was based on Lehrer's (1993) analysis of design skills necessary for student authoring of hypermedia, and the teachers had consulting help from both Lehrer and the researcher to initiate the hypermedia projects in their classrooms. This study took place during the second year that the teachers had worked with the hypermedia-based curriculum: The first year was a trial project, whereas this second year focused on the skills that students learned through design and on the development of new types of assessment tools. The teachers used portfolio assessment and other assessment tools that students and teachers created together. Throughout the year, the teachers encouraged student autonomy.

During the school year, the teachers provided their students with an instructional framework of research and design skills (Appendix A) to assist them with the cognitive skills of hypermedia-based design (Lehrer, 1993; Lehrer et al., 1994). Through designing several hypermedia documents about social studies topics (e.g., cultures of the world), students were encouraged to focus on developing and refining such skills as finding information, creating new information, analyzing and organizing information, presenting to others, and reflecting on a topic and its connection to that of others. As students worked through each hypermedia project, teachers urged students to think about how best to communicate their topic to others. Should information be represented through text, graphics, sound, or pictures, and in what combinations? How should a document be structured so that others might read it? Teachers' goals were for the classroom to become a community of designers, where students and teachers were working together, sharing ideas in a collaborative effort to learn more and to share what they had learned with others.

Hypermedia projects. The teachers had sequenced the projects during the year to move from hypermedia designs about students' personal concerns to concerns about the world, from "Who am I?" to "What is my place in the world?" (Wilhelm, 1995). Thus, the school year began in the fall with students designing a small hypermedia document (a few cards) in order to learn to use the hypermedia programming tools (Hypercard).[3] Students created a document about themselves called a personality profile to share with their peers so that the class could get to know one another.

[3]Throughout this paper, the terms "document," "composition," and "stack" are used interchangeably to refer to students' hypermedia designs.

About a month later, students designed a stack about their opinions on the O. J. Simpson trial to refresh their learning of programming tools. The stack served as a point of discussion about organization of information (e.g., prosecution, defense, strengths and weaknesses) and was not graded.

Following these few days of stack design, students began the next hypermedia project. The 3-week long project followed completion of a psychology unit in the social studies class. This was a research project in which students were to pursue a research question related to a topic covered in class. Students were asked to choose a research question, break it down into components, find the information, and organize and design an individual hypermedia document so that peers could learn about the topic.

The final project involved working in collaborative design teams over the course of 3 months to create a hypermedia composition about a culture (country) of the world. Design teams first selected a culture of interest, and decided what areas (subtopics) of culture each member would research. Then students asked research questions, found information (including an interview with a person from the culture), and organized and designed a hypermedia composition. Students evaluated the designs, and they were provided with a period of revision for hypermedia documents.

Students worked on these projects during one or both of their reading and social studies classes anywhere from 2 to 5 days per week. The students had access to a computer lab with approximately 28 Macintosh computers and 1 scanner. The teachers provided the instruction on hypermedia programming to each of the classes during the initial personality profile project and on other more advanced programming (e.g., animation, sound) throughout the O. J. Simpson and psychology projects.[4] If there were not enough machines for each student to work on the computer during a class period, teachers had students work on their project away from the computer (researching, reading, designing plans) or peer-tutoring in the lab. Students sometimes worked in the classroom or library (often in the beginning of a project) and worked in the computer lab at other times (toward the middle and end of projects).

Data Collected

Various data were collected to permit the investigation of both qualitative and quantitative questions about the instructional and learning environment. This paper reports initial qualitative analyses of classroom development over the year.

My role was as researcher, conducting interviews with students and teachers and collecting data. I was part of a two-member consulting team that met with the teachers twice during the summer for planning meetings. During the school year, I conducted interviews and had conversations with teachers at five points throughout the year. Teachers did not receive in-service training or have external experts to help them with day-to-day teaching; once the year began, curriculum planning and all instruction were developed by the teachers.

The teachers were asked to keep journals throughout the school year during each hypermedia project. In addition, I collected sample field observations of classroom instruction and videotapes from select lessons (such as development of class assessment rubrics and mini-lessons on organizing information). Each teacher was interviewed five times throughout the school year. Initial qualitative analyses of these data are reported in the results and discussion section in order to detail the classroom practices and challenges posed by student-designed inquiry throughout the year.

Results and Discussion

The following sections trace the development of the classroom toward a community of designers, detailing the practices that teachers used to redesign the learning environment in the classroom. I primarily use data from one of the teacher's journal entries, as well as interviews and field observations as evidence to illustrate my analyses of classroom development. Except where noted, the excerpts below are taken directly from Mark's journal entries.[5] The first section describes the classroom structure. If the structure of traditional classrooms were removed, what would be left in its place? What would be the new roles for teachers and students in the classroom? The next section explains obstacles to the changes that were taking place in the learning environment. The institution of school is based on certain conceptions of learning in the classroom. Many of these institutional structures (allocation of time, materials, classroom location) and the people in those institutions (students, administrators, other teachers) have conflicting notions of "schooling" that pose challenges to the changing nature of learning and instruction. The final section outlines the development of the classroom as a community of designers, detailing various aspects such as classroom discourse and communal sharing of knowledge. It also includes a discussion of the classroom as a place of multiple zones of proximal development, with distributed expertise of knowledge and the computer as a powerful tool for learning (Brown & Campione, 1994; Campione, Brown, & Jay,

[4]The teachers did not receive in-service training or classes in computer programming; rather, one teacher purchased a book on Hypercard programming and taught himself and the other teacher.

[5]The particular teacher and student names are not real names, but pseudonyms.

1992). Following the three main sections of classroom structure, challenges, and development into a community of designers is a section on teacher conceptions of student learning.

Structuring the Classroom Toward a Community of Designers

This section describes the common classroom structure and routines as well as several of the key instructional practices that were important for the success of that classroom structure. Next, the teachers' view of their new role in the classroom is discussed, detailing their new challenges and opportunities for instruction. Finally, the students' role in the classroom is presented.

Classroom Structure

What were the common routines that characterized a structure for student learning in the classroom? Traditionally, we have a structure where discourse is a cycle of recitation: (a) a teacher asks the class a question, (b) a student answers, and (c) the teacher corrects or evaluates the student's answer (Nystrand & Gamoran, 1991). But in this study, the general classroom structure was *student*-generated inquiry. The class moved through cycles of student-designed curriculum throughout the year, and teachers used various instructional practices such as work stations to assist students in moving through the process of inquiry. Also included in the cycle of research and design was the creation of an assessment rubric by students and teachers together. These three features are discussed below.

Research and design cycles. Students and teachers moved through cycles of research and design (in both reading and social studies classes). Teachers provided students with a handout in the beginning of the year explaining the process for the research and design cycle (see Appendix A). Students asked questions, found information, and developed new sources of information (i.e., interviews, dramas). They analyzed and organized the information in a way that made sense to them and to an audience of peers and then designed hypermedia documents to teach others about their topics (for more on this framework of research and design skills, see Lehrer, 1993; Lehrer et al., 1994).

This cycle of research and design also provided time for student reflection at multiple points throughout the process. Students wrote in their "designer diaries," detailing their reflections and plans during each hypermedia project. Reflection also included evaluating other students' work, both in whole group discussions and in peer review or group critique sessions. The following journal excerpt explained the importance of these periods of student evaluation:

> Giving time to view, critique, revise and do a new project of the same type where they can apply what they have learned all seem to be essential ingredients in helping students to learn from projects such as these.

Finally, the process of research and design included time for students to refine their designs, incorporating feedback they had received from their peers. In the following journal entry, the teacher noted how students were beginning to include revision as part of the process of research and design:

> Kids are designing, critiquing, improving. When they have a good card they are starting to ask how it can be made better with more information, popup fields, icons, animation. They seem pretty good—once they have a good card—about designing effects that actually will help them and a reader explore and understand the topic.

This classroom structure recurred many times throughout the year, becoming a "ritual familiar participant structure" (Brown & Campione, 1994). Students came to know and follow the overall research and design process (ask, find, develop, analyze, organize, design, reflect, refine), but the process also emerged in their work at another level, within a particular skill. For each cognitive skill that students engaged in (e.g., organize), teachers provided multiple opportunities for practice, reflection, and revision of the skill. For example, the teachers assisted students with the skill of organizing information by providing multiple opportunities to practice. Students organized their information into webs, issue trees, power outlines, and so forth. The difference between forms of organization is not so important to this paper as the fact that students practiced the cognitive skill of "organize" in multiple settings. In addition, these practice opportunities often moved through phases, from whole group discussion to work in pairs to individual work (presented for small group critique). Thus, teachers established both of these recurring cycles in the classroom; students had multiple opportunities to practice both the overall process of research and design (a cycle across all skills) and each of the particular skills involved in that process (a cycle within a particular skill area).

The teachers developed a checklist (see Appendix B) to help students move through each step in the research and design process, requiring that each step be initialed by a teacher upon completion. This gave students both a way of knowing "what to do next" and an indication of what they had accomplished:

> We like the structure and accountability provided by the checklist, though we continue to make

> modifications on it. This seems to guide kids who have a lot of initiative about where and what to do next. For kids with less initiative or organization it seems to communicate where they are and what they need to do and get them off their duffs: we've had few questions about expectations and much more productive workshop time. It doesn't seem to hamper creativity and yet provides focus so freedom is exercised in a wise and productive manner, e.g. [cites specific students]—kids who might get behind have a way of monitoring themselves.

In addition to providing students with a way to monitor where they were in the research and design process, the checksheet also provided teachers with a method of monitoring student progress:

> The checksheets we devised to monitor what info students have found and read are proving invaluable for keeping track of where students are. Now we know that everyone has found multiple information sources and has done some reading. We are confident that no one has completely fallen through a crack in the floor.

In summary, the teachers used a repeating cycle of research and design to structure student learning throughout the year. Teachers used checksheets to assist students with the process of research and design as well as to monitor their progress. The cycles of research and design became the common routines that provided structure to learning and instruction throughout the year.

Work stations. Another common routine in the classroom was a restructuring of locations (both of the classrooms, the computer lab, and the library) into "work stations." The teachers devised "stations" to assist students with individual needs at different points in students' work and in the research and design cycle. Some students needed work on the computer for hypermedia design, some needed the library for researching information, and some needed individual help or time for working with group members.

Since there were two teachers involved in the collaborative projects, each teacher staffed a different location in the building where students could work (i.e., computer lab, classroom). The teachers also had assistance during these times from a student teacher and the learning disability teacher, who staffed different locations or provided different types of student assistance. This enabled students to work during both reading and social studies periods (45-minutes each) in whatever location they needed at a given point in time (library, classroom, computer lab). Teachers provided work stations at different points in the design process according to differing student needs.

The work stations allowed students to move through a more authentic design process. Designers often move back and forth between various local and global constraints in design, in a recursive process (Erickson, 1994; Lawson, 1990; Voss, Greene, Post, & Penner, 1983). Too often, student design projects in school follow a linear process: The steps are sequenced so that students gain each step in a process, but only move through one step at a time (and only one pass through each step). Although one might expect the checksheets to constrain the recursive nature of the design process, this was not the case in this study. Because the work stations provided an environment of flexibility for adding or revising information, the students did not seem to be constrained by the linear nature of the checksheets. For example, when students began to design their computer screens, some found they had not gathered enough information, which led them to a return trip to the library or other work station. The journal entry below described how the stations allowed for a more recursive design process:

> The stations also allow for more individual pacing and more recursive work: even kids who are done with a few computer cards can go back to the library or classroom to read, research, work with group members on peer review or cross-linking.

In addition, the stations allowed the teachers to provide a more individualized pace for their students. In traditional computer projects, a teacher must sign up for designated time in a computer lab. This means that even students who are not ready to design at the computer often work in the lab because that time has been scheduled. But in this study, the teachers' instructional use of stations allowed only students who had a need to be in the lab to work there.

Finally, since the teachers in this study found that computers were a motivating factor for students, they required an "entrance pass" for getting into the computer lab station. Students needed to demonstrate that they had gathered and organized sufficient information and had plans for the design of their documents before they were allowed to work in the lab.

> Stations system is working. Jill [the LD teacher] is excited about this. She says "kids don't get to eat their cake without eating their broccoli." For most kids, and hers as well [learning disabled], working on the computer is a treat that they want. Now they don't get to do it unless they have the entrance ticket of a completed checklist. This is motivation for them. It also provides them with individual guidance if they are behind because they

Table 1
Class-generated Assessment Rubric for Psychology Project

EVALUATION RUBRIC FOR PSYCHOLOGY HYPERMEDIA PROJECT NAME _____

OUTCOME	EXCELLENT	ACCEPTABLE	NOT ACCEPTABLE
Media Inclusion Value = 20 points	Student includes three imported media examples.	Student includes one imported media example.	Student does not include imported media.
Stack Organization & Function Value = 20 points	Stack organization follows an easy to use title card. The stack organization aids the browser's understanding of the stack content.	Stack organization follows an easy to use title card. Stack organization does not get in the way of browser's understanding of content.	Stack does not follow the title card. Stack organization gets in the way of browser's understanding of content.
Information Quality Value = 20 points	Information is divided properly and is written well. Topic is covered completely and text has great grammar and spelling. Fields have been used properly.	Information is divided and written with only a few problems. Each field has two or less grammatical and spelling errors. Adequate coverage of topic.	Topic coverage has gaps. Fields that have more than two errors of grammar and spelling. Poor text passages.
Link Quality Value = 20 points	Reasons for all links, button names, icons, and effects are clear and warranted.	Very few mysterious links, button names, icons and effects. (Less than two)	Many problems with links, button names, icons, and effects.
Research Quality Value = 20 points	Four or more sources have been used. All sources have been cited properly on a source card connected to the main menu card.	At least two sources have been used. Sources have been properly cited on a source card connected to the main menu card.	Less than two sources have been used. Sources are not cited properly. Source card missing or incorrect.

> go to the station for researching or designing and get help for where they are at this point.

Students were motivated to get into the computer lab, and were thus motivated to complete their work at other stations.

In summary, the teachers found that the technique of creating work stations assisted students in the research and design process in a way that was both sensitive to the needs of individual students and promoted a more authentic process of design.

Assessment. At the beginning of each design project, students and teachers together developed an assessment measure to help them determine the effectiveness of student design and student learning. The class together developed criteria by which each hypermedia project would be evaluated; they constructed an assessment rubric so that everyone knew what "standards of design" were needed for a "good" hypermedia document.

Table 1 shows the class-generated criteria for the psychology stack. To get to this point, the community evaluated hypermedia projects from both past years and present student work. Teachers asked students, "What have we learned from the last project that we are going to incorporate this time?" (Field Observation, February 8, 1995). From these evaluations, the class discussed and created the assessment rubric that outlined the criteria for "excellent" versus "acceptable" versus "not acceptable" student work.

Table 2 displays another evaluation rubric for the final hypermedia project on a culture of the world. Again, there was a class discussion in which teachers asked students what they had learned that they could now incorporate into a new assessment rubric. Note that the criteria in the new rubric had increased in sophistication for quality of work. For example, to receive an "excellent" in the psychology project rubric (Table 1), a student needed to incorporate three media examples (e.g., sound, pictures). However, in the culture project (Table 2), an "excellent" required that

Table 2
Class-generated Assessment Rubric for Culture (Country) Project

EVALUATION RUBRIC FOR CULTURE HYPERMEDIA PROJECT NAME _____

OUTCOME	EXCELLENT	ACCEPTABLE	NOT ACCEPTABLE
Multimedia Card Space Justification Value = 20 points	Card space has been thoughtfully used and author can justify use of card space.	Author has less than 25% of stack cards that she cannot justify space use. Points will be deducted in proportion to number of problem cards for the size of the stack.	Author has 25% or more cards that she cannot justify space use.
Stack Organization & Function Value = 20 points	Stack organization follows an easy to use main menu card. The stack organization aids the browser's understanding of the stack's content.	Stack organization follows an easy to use main menu. Stack organization does not get in the way of browser's understanding of content.	Stack does not follow the main menu. Stack organization gets in the way of browser's understanding of content.
Information Quality Value = 20 points	Text is written in author's own words, is interesting to read, grammatically correct, and properly divided.	Topic covered well but has problems with grammar, division of information, use of own words, or being boring to read.	Topic coverage has gaps. 25% or more of the cards have problems with text.
Button Quality Value = 20 points	Reasons for all links, button names, icons, and effects are clear and warranted. More than one cross link made in stack or to another stack.	Some mysterious or unjustified links, names, icons and effects. Points will be deducted in proportion to the number of problems and the size of the stack. At least one cross link made in stack or to another stack.	Five or more buttons have problems with links, names, icons, or effects. No cross links made in stack or to another stack.
Audience Involvement Value = 20 points	Audience is made to feel involved throughout the stack. Involvement is interesting and maybe even fun.	An attempt has been made to involve the audience. Points awarded depend on effort made throughout the stack.	No observable attempt has been made to involve the audience.
Research Quality Value = 20 points	Three or more primary and secondary sources have been used and documented. Two of the following have been used: interview, follow-up, or artifact.	Two primary and secondary (myth, story, video, etc.) have been used and documented, along with one interview and one artifact. Points may be deducted if information not adequately covered.	Less than two primary and secondary sources, one interview, or one artifact used and documented.

students "thoughtfully use" and justify their use of space on a particular screen, a move from the inclusion of *any* media—often for purposes of "flash"—to a *justified* screen design that required an examination of one's purpose and audience (Erickson & Lehrer, 1996). An "excellent" now also included developing one's own sources of information (e.g., interview or artifact) and included audience involvement in one's design. These changes showed more sophistication of design criteria than the psychology project. More importantly, the changes were added by the students, who were requiring more sophistication in the hypermedia designs and process of design.

In summary, the teachers and students together developed assessment rubrics. These were developed at the beginning of each project so that everyone knew what standards of design were expected. Teachers used this activity to ask students what they had learned that could be incorporated into a new project. Thus, the class could reflect on student learning and design skills, and teachers could assist with increasing the level of sophistication for standards of quality (Erickson & Lehrer, in press).

Teachers' Role

Teachers needed to redefine their role within this new classroom structure of student design-based inquiry. How would they deliver instruction? How would they spend their time? Building a community of designers necessitates decentralizing the traditional role of the teacher and distributing the instruction, evaluation, and knowledge across the classroom community (Erickson & Wilhelm, 1996; Lehrer et al., 1993). How does a teacher accomplish this difficult challenge? The following journal entry illustrated how the teachers viewed their challenge:

> Bob and I have discussed several times how our job has become tougher. We need to start recognizing and rethinking the underlying processes kids use to find information, ask questions of it, organize and construct meaning from what they find out. How can kids be helped to learn from text? from artifacts? What do they need to do to converse with authors, recognize main ideas, differentiate these ideas from supporting details? How can we recognize what they are doing and not doing? How can we help them to do that which is difficult for them. This seems to be the substance of our challenge. What must happen for other things to happen?

The teachers in this study reflected on how best to help students gain the cognitive skills of research and design, and how to sequence the process of student inquiry. This new role for the teachers was quite difficult. The teachers needed to assist students in constructing understanding (the "how") versus their previous role of transmitting information (the "what").

Although the teachers needed to aim instruction at student needs, it was difficult to predict or plan what students would struggle with and where they would need guidance. Therefore, instruction required a new and challenging approach—instruction that was emergent with student need:

> We could not predict what kids would have difficulty with, or the degree of difficulty. As a consequence, we have spent many nights designing instructional sequences to help kids overcome their problems at the point of need. What's hard is that we're tired and staying up late and not all of the assignments are as good as we'd like. What's good is that the assignments address a real need, at the point of need, in a project the kids are pursuing.

The teachers felt that they could not plan a unit because their instruction depended upon the emerging needs of the community. Thus, the teachers felt they needed a new mix of teaching abilities—including a wide repertoire of teaching strategies, knowledge of student cognition, and flexibility—in order to achieve emergent instruction:

> Mike, my student teacher, is a bit overwhelmed with the whole idea of mini-lessons. First we have to engage ourselves with the student and their work, familiarizing ourselves with it and identifying recurring problem patterns. Then we have to quickly come up with a way of using student examples to contextualize a mini-lesson for tomorrow's classes.
>
> .... This has made me think how student designed learning demands a very different role for the teacher. In traditional classes the teacher knows the material and is the expert on it. The teacher can plan out sequences of lessons for the whole year in advance. In our student design classes we set up general parameters and support systems and then we have to see what topics, questions and problems the kids come up with and then help to deal with and solve those. We become much more of a learner among learners, a guide or a facilitator.
>
> I think that running a student design classroom requires experience, a wide repertoire of teaching techniques and lessons, confidence in self, confidence in kids, confidence in an articulated learning theory, willingness to work through problems at a moments notice, willingness to work day by day as far as specific lessons go. This requires let-

> ting students explicitly or implicitly set the agenda, which requires giving up a measure of control over the classroom.
>
> Bob, Jill and I all agree that this is more exciting and interesting teaching, but that it is harder, more nerve-wracking, more challenging and difficult. I think it would be hard to pursue without collegial support, which we luckily have in each other and [the researcher].

It is worth noting that both teachers in the study engaged in ongoing reflection of their instructional practice and its effectiveness (in addition to the journals and interviews). On their own initiative, they spoke often during the school day about the project and student learning. The teachers sought to improve upon the methods they were using to support student design.

> Have we given the kids too many requirements/ expectations at once? Or is this important—to understand up from the depth and complexity of the project. Some kids seem overwhelmed and panicky—even though we have moved slowly and even though we are supporting each aspect of finding and organizing information in our classes—many kids seem to look at what will eventually be created and freak out.
>
> Should we have started earlier? Or is it good that deadlines are in sight and that there is a sense of urgency?

This type of reflection was typical of both teachers participating in the study. They reflected on their instruction and on student learning, discussed issues (almost daily) with one another, and made revisions in their practices based on that reflection.

Although the teachers found their new role to be challenging, it had certain rewards as well. The teachers reported that they were thinking deeply about student learning and their own instruction:

> I don't know if I've mentioned before the added benefit in this project of how much and how well Bob and I are communicating as teachers, and how deeply we are thinking about the necessary strategies and processes for students to possess as they pursue the project, and how we can help to develop these. In past years we only got together for planning and very brief sorts of "post-mortem" evaluations. Now we talk every day, speak about what we have noticed, brainstorm new procedures, possibilities and directions.
>
> I think that we also get to know the kids and their abilities in a way that is unavailable to most teachers. We get to see the directions their minds naturally take, and where they bump up against their limitations. We have to know what they are doing and thinking or we cannot guide and help them appropriately. Other teachers on our team have remarked that we seem to know the kids and their abilities better than they do, and sometimes ask our advice about addressing particular kids' needs.
>
> . . . . This sort of student-design project helps you to know how they think and how they learn.

In summary, the teachers conceived of their role as model and guide of the research and design process. This meant that instructional practices focused on emergent instruction (mini-lessons to meet particular student needs), and that teachers analyzed and reflected on students' thinking. Teachers were engaged in ongoing reflection and revision of the learning environment.

Students' Role

Teachers reported that students viewed their role as both individual learner and member of a community.

> There . . . seems to be some minor problems emerging about the balance of group and individual responsibility, but not as much as we thought. Because each kid is responsible for a stack he knows he has something to do for which he is personally responsible. Because they are working together to complete a thorough project students are generally interested in what other group members are doing, in motivating or helping them if they are behind.

Teachers devoted time to peer review processes to encourage students to help one another evaluate, discuss, and revise their designs. They shared ideas, provided feedback and assistance to one another, and moved toward what Brown and Campione (1994) call "individual accountability coupled with communal sharing":

> We're seeing lots of this quick-hit help and explanation between students. Some of it is structured into the peer review process but much of it is also encouraged because we don't know the information about certain computer skills and content knowledge or because we are too busy. We become learners among learners and this really encourages them to turn to each other. I think this is a powerful move for a teacher, to become a learner

> rather than the expert director, and I think that it liberates the kids too, though often they have to rethink how they will do things in the classroom, e.g. who they will ask questions.

Because teachers did not have sole ownership of all knowledge and authority, students were encouraged to turn to one another for assistance. They not only worked on their own research and design, but also provided assistance and feedback to other members of the classroom community.

Obstacles to Creating a Community of Designers: Redefining the Nature of "School"

The institution of school is based on certain conceptions of how to implement learning in the classroom. Many of these institutional structures (allocation of time, materials, classroom location) and the people in those institutions (students, administrators, other teachers) have conflicting notions of "schooling" that pose challenges to changing the nature of learning and instruction. Teachers in this study reported two main obstacles to the changes that were taking place in the learning environment: student conceptions of "school" and administrative/institutional notions of "school."

Changing Student Conceptions of "School"

> Many kids have expressed surprise that this is an integrated unit with both reading and social studies. Although we were explicit about it from the start, kids would say things like "Hey, we're doing this in social studies too!" Even now, kids will ask, "Why are we doing the same thing in here and social studies?" Rhonda asked this again yesterday. Why not, I asked, you can cover twice as much ground. "Because reading is supposed to be about reading and social studies about social studies. They're not the same thing and you shouldn't be doing the same thing." I explained to her how reading was about constructing knowledge from text and how social studies was about constructing knowledge about the topic of social studies from texts and other sources of information. I told her that we need to learn how to read texts and pictures, music, people, etc. "It's not the same thing or they wouldn't give the classes different names," she insisted.

This journal entry illustrated how student notions of schooling were obstacles to redesigning the nature of the learning environment. Although students were working on an integrated project, they insisted that the classes ought to be "separate." A collaborative design project such as in the current study challenged student conceptions about the nature of school activities and about the nature of "separate" domains.

Teachers reported that this may be particularly problematic for students who typically do well in school, students for whom "schooling" comes easily. The teachers in effect "changed the rules"; they changed the structure of activity as well as the criteria for success in this new learning environment. The following journal entry described the challenge posed by students who were accustomed to being successful in school:

> There is a group of students who are typically good at school who are struggling with this project, and generally resisting it. Molly even said to me, "Why can't we just do worksheets like in other classes?" Because here we are learning, creating knowledge organizing what we have found out and thought and present it to other people so they can learn what we have learned, I told her. "I don't want to do that, I just want to do my work and get a good grade," she said.
>
> The project is messy, difficult, challenging, and it doesn't fit these students' ideas of what "school" is all about. It's interesting because we started the project, and each new phase of the project, by explicitly stating the objectives, and asking the students to list times and situations in their lives when they would need to be able to know and do the objectives. Despite our attempt to make the learning real in the near term (teaching others, sharing projects in the community) and long term (how this will help you in your life), some students would rather do "school" which they know how to do and know they can be successful at.

This excerpt demonstrates how student-design environments pose challenges to students' traditional notions of schooling. Teachers reported that students for whom schooling "was easy" were resistant to changing the typical structure of the classroom.

In addition to redefining "school" for students who are typically successful, the teachers reported that student-design also affected students who are typically not successful at school:

> One thing that is very frustrating but revealing about the project at this stage is how naked the goof-offs become. Bob and I have discussed this at length and we agree that these kids are great at concealing how little they do in a regular classroom—or at just accepting failure rather than doing any work and being allowed to do so.

The entry above illustrates how the student-design curriculum required students to integrate and perform a multitude of cognitive skills, which was particularly difficult for students who struggled simultaneously in multiple skill areas (Field Observation, February 16, 1994).

One particular skill—revision—posed challenges to student conceptions of "school." Revision is a difficult skill that is typically not taught in school (Lehrer et al., 1993). When revision is included in the curriculum, it is often a "one-time" revision. The teachers in this study, however, tried to help students understand that revision is a necessary part of design, on an ongoing basis (not just revising one's writing or design, but revising the questions one has asked, the information one has found, and so forth):

> Bob and I spoke this morning about how many of our students, most remarkably the better ones, think that if they have written down anything at all for their issue tree [organizing information] that they're done! Somehow they lack the ability to see if something is complete or partial. They can't see if what they have doesn't adequately cover the topic.
>
> . . . . The problem with a culture [hypermedia project] without much information is that the kids think they should be done with less information. They have expressed the idea over and over that if they have found "something" that that's enough—like research is a scavenger hunt or something.
>
> . . . . Bob and I have both been going to great lengths to tell the kids that they have been doing a great job, but that the issue trees are designed to show them how the information can be organized in the stacks, AND to show them what information they still lack. They seem to feel they have failed when they see something else to do.

The students initially conceived of revision as a failure, as opposed to a necessary part of the research and design process. Similar problems have been found for the revision process in the literature on writing (Bruer, 1993; Hayes & Flower, 1986; Scardamalia & Bereiter, 1986).

In summary, teachers tried to change student conceptions of "school" from notions of "separate subjects" to that of integrated inquiry. Teachers reported that this process changed classroom dynamics and criteria for "who will typically succeed," and more easily identified students who were struggling. In addition, the revision skill posed particular problems. Students needed to continuously assess, revise, and refine—a difficult process for student designers because it is in contrast to student conceptions of "what school is all about."

Changing Administrative and Institutionalized Notions of "School"

In addition to changing student notions of "school," the teachers faced challenges from administration and other teachers as well. Teachers reported that other faculty members were suspicious of the changes they were making in the classroom. The following excerpt described how other teachers at the school were resistant to change:

> Today I'd like to comment on the interest in our project expressed by the faculty and administration. We have been closely questioned by several people over the past few days about the nature of the project.
>
> . . . . There are other examples too. It's interesting that the interest has almost been entirely resistant, sort of like: "don't get me involved in this too."

Also, institutional structures (the length of a class, materials available, locations) posed challenges to changing the nature of the classroom environment. The journal entry below summarized how many of the institutional structures made it difficult for the teachers to change the nature of learning and instruction (and to participate in research of this nature):

> Bob, Jill and I have all talked several times about how our experience with this project just shows why teachers are dissuaded from trying new things in their classroom, and from researching what they do. The first issue is time. There is not time for developing the new lesson plans. We were given two half-days, for which I suppose we should be eternally grateful. We have spent literally hundreds of hours planning, learning the hypermedia ourselves, and now developing daily plans, monitoring progress, figuring out what we can do to support and guide kids through local problems, etc. Working out lessons for strategies to organize information (pyramids, issue trees) took several hours just on its own.
>
> Another problem with time is the schedule. Some of this design stuff takes hours of sustained thought, collaboration and creativity. Kids will get started on something, get an idea, and RINNNG—the bell rings. We're really limited in how kids can collaborate because of the schedule. There are times we'd like to get all three teachers together to do something—but NO Can DO. We've requested block scheduling the last three years so

> that we could address some of these problems as a team, but our requests have always been denied.
>
> Secondly, there is suspicion of anything new—to which I have alluded earlier, and you always seem to be under scrutiny with everyone asking questions. I guess this isn't really so bad because it gives you the chance to disseminate information. The con side is that it takes more of your time and some of the people aren't interested in learning about the project but in pointing out why it can't or won't work.
>
> Thirdly, there's no easy way to get the materials that you need, especially if you suddenly find a need.
>
> It point outs, I think, the need to reconceive of school in terms of time. School will not essentially change until we change how we use and schedule time.

This entry demonstrates how institutional structures, time in particular (i.e., in 45-minute blocks), affect how well students are able to work, design, discuss, and evaluate. The teachers in this study described many struggles against institutional structures; there were no structures in place to support this type of student inquiry in the classroom or their new roles as teachers (CTGV, 1994).

In addition, the school did not provide enough computer support. There was a computer teacher at the school; however, he needed to teach his own courses and to run the computer lab. This meant that the teachers, during class time, had to both instruct their classes in Hypercard programming and to solve any computer problems that arose:

> In our school it's basically up to us to fix things—there's nobody around who has the time and energy to fix it. As a result we've learned a lot ourselves about computer problems and how to fix them. We try to make it a learning experience for the kids too. "So the computer says the user level won't permit you to do this. What do we need to do then?" "Do we know how to change the user level?" "How could we find out?"

The teachers used these problems as opportunities to model for students where one finds information or how one thinks through a problem (Collins, Brown, & Newman, 1989). The teachers encouraged the class to rely on one another for solving problems and assisting with finding out about needed knowledge.

One teacher summarized these instructional challenges to redesigning learning environments in this way:

> Is there a moral to the story? Perhaps it's that finding information is a difficult process that takes a lot of time. Maybe we rush through units and kids don't really learn how to learn.

These types of student-design environments that attempt to build communities of learners typically require more time and more depth than traditional curriculum (Brown & Campione, 1994; CTGV, 1994; Lehrer, et al., 1994; Scardamalia, Bereiter, & Lahmon, 1994).

Classroom Development Toward a Community of Designers

The following sections characterize how the classroom developed over the course of 1 year toward a community of designers. Such a community decentralizes the traditional role of the teacher and distributes instruction, evaluation, and knowledge across the classroom community. Since the changing roles of teachers and students have already been discussed, the sections below elaborate on other aspects of classroom development. For example, what was the nature and role of classroom discussion? How did the sharing of ideas and assistance take place? How did computers play a role in student learning?

The sections below depict the development of the classroom over the school year. First, the teacher's view of the classroom as a place of multiple zones of proximal development is presented. This includes a description of how the teachers used computers as powerful tools for learning and capitalized on students' developing expertise in various areas of content and skill. Next, the nature of discourse is outlined, followed by a discussion of how the community members shared and appropriated ideas.

The Classroom as a Place of Multiple Zones of Proximal Development

Because teachers were busy and lacked institutional supports, they capitalized on students' developing skills and on powerful tools to assist with student learning. Brown and Campione (1994) suggest that people and powerful materials in the classroom can enable what Vygotsky (1978) called zones of proximal development.[6] That is, both people and powerful materials can push the upper boundaries of learners' competence, developing it to ever more advanced

[6]Powerful materials are those that change the nature of a problem or task. For example, giving a child manipulatives to assist with addition or subtraction might be considered powerful materials if it reorients the nature of problem solving. Computers may be considered powerful tools, but are not necessarily the only powerful materials in the classroom. See Brown and Campione (1994) for more on powerful tools and multiple zones of proximal development.

levels (Brown & Campione, 1994). For example, peers may help a particular learner to reconceptualize or reorganize a problem, and thus assist with cognitive development.

The classroom can be viewed as a place of multiple zones of proximal development. Zones of proximal development can include both adults and children with varying levels of expertise and powerful artifacts such as computers, books, and other materials intended to support intentional learning (Brown & Campione, 1994; Scardamalia & Bereiter, 1991). The teachers viewed their classrooms as students in "multiple places" of cognitive development, sharing ideas and strategies with one another, and helping to push each other to ever more sophisticated kinds of thinking and designing. Their use of students' developing expertise and of computers to support learning is outlined below.

Capitalizing on distributed expertise. As students began to develop skills on the computer, knowledge of content, strategies for designing, and so forth, the teachers used the students' varying expertise in order to assist with problem solving. Teachers called upon students with particular skills whenever a need arose, in order to solve a problem:

> We were talking today about strengths of the project. First there is distributed expertise, point of need mentoring and flexibility. . . . When I'm in the computer lab and there is a problem, I usually just say, "Hey, has anybody in here unlocked a text field . . . created animation . . . know how to make/import a graph?" Most of the time someone does. I have never witnessed a kid be reluctant to teach someone else what she knows. This is kind of amazing.

Some students had become skilled at particular aspects of computer programming, some on content, and others on the process of research and design skills (e.g., organizing information). Teachers used this to their advantage, calling upon these "experts" to serve a particular need of an individual or group.

> We're seeing some distributed expertise, especially regarding computer skills and expertise, and quite often it is coming from at-risk or learning disabled kids. This is what happened last year too. About half of our labeled kids became competent if not stellar students on the hypermedia projects. Chad became a resource for Icon editing and design. Terry for animation. Doug, so often a behavior problem, for scripting and creating games, moving and deleting buttons and fields. Doug, after getting attention as a resource, worked incredibly hard on his design cards so he could get on a computer. . . .
>
> Other kids seem to be becoming experts on the process of finding and organizing information. Again, some of these are the at-risk kids. Dale, e.g. was helping Thad organize info and was reminding him of "what's your research question?" Jay was helping Jim do his sub-topic plan and was correcting what he considered ill-advised cross-links. We're seeing lots of this quick-hit help and explanation between students. Some of it is structured into the peer review process but much of it is also encouraged because we don't know the information about certain computer skills and content knowledge or because we are too busy. We become learners among learners and this really encourages them to turn to each other.

Although the teachers' role had become more difficult and hectic, they were able to capitalize on the developing skills in the community in order to provide assistance with problem solving. The teacher was not the sole expert or "fixer of problems"; rather, the community helped one another to solve problems as they occurred.

The fact that classroom members were developing skills in multiple areas meant that students were often at different "places" in the processes of learning and designing. This meant that problems were solved when they were needed, often by other members of the community. The following journal entry explained the value of allowing students to move at individual paces, solving problems at the point of need:

> The system provides for a kind of point of need mentoring. When a kid needs to know something, someone helps them to do it, or helps them find out. As teachers we are busy all the time, but the kids are busy too—problem solving, helping each other, etcetera. Mike couldn't open his stack because of a password. Sam, Jerry and several other "goof offs" came over and diligently made suggestions for about ten minutes until the problem was solved. They were totally engaged by the problem and eventually solved it.
>
> Also, Bob [the other teacher] often mentors me. If I come across a problem with a kid's stack he'll spend time later in the day helping me to understand it. I help the [learning disability teacher]. I help kids. Kids help kids. It's the best kind of learning circle. And when the mentoring is going on, the kids have a very real and personal need to find out.

This may be viewed as students in "multiple places" of cognitive development, sharing with one another and

helping to push each other to ever more advanced ways of thinking and designing—multiple zones of proximal development.

The role of technology: Computers as powerful tools. It takes time to perfect, develop, and implement a community of designers. Computers can be used as powerful tools, assisting students with cognitive skills such as reflection and objectification of knowledge (Brown & Campione, 1994; Campione et al., 1992; Harel & Papert, 1991; Lehrer et al., 1993; Scardamalia, et al., 1994). However, it is often difficult for teachers to learn to use these tools in a way that is beneficial for student learning:

> We are having new and more sophisticated problems with the computers and discs too. Some of the kids used reformatted discs and these are all breaking down so we are having them save their stacks on student folders on the hard drives. Some kids have passwords which then screw up and freeze their disc, so we've had to learn how to figure that out. I solved two problems today.

It was not easy for the teachers in this study to learn the computer skills needed, and at the same time, to see the value of the computer for student learning. However, the second year of implementation (recall that this was the second year teachers used hypermedia-based inquiry) was easier than the first, enabling the teachers to improve and focus on more conceptual issues like the role of the computer in student learning. The following excerpt discussed this change in the first to second year of implementation:

> My own role: I noticed that I'm looking more at content than actual hypermedia use, which clearly dominated my attention while teaching this unit last year. Why? Perhaps because I'm more familiar and comfortable with hypermedia. Probably because I see it as a tool for teaching, encouraging and extending certain skills and abilities like organizing. At any rate, I'm pleased with this change in emphasis since it means I'm concentrating on what I want to focus on: helping kids to be better thinkers, readers, and writers.
>
> I also found myself encouraging students to use more of the hypermedia's potential—last year I was pleased just to have them fill out fields, scan in pictures and have working buttons. [This year] I found myself often saying: "You're just telling this like a list . . . remember what you can do here to organize this for the reader." "All you've done here is tell about your experience. What other media do you have at your disposal?" Etcetera.

Papert (1980, 1992) suggests that computers can be used as "objects-to-think-with." One teacher reflected on the way in which the computers were helping students to reorganize their knowledge (in addition to being a motivator for students):[7]

> I am noticing, though, that the stories and factual knowledge the kids have accumulated become "tools" that they think with or think from. We have worked in the Reading class on questioning, categorizing, linking and presenting information. None of this works if the kid hasn't gathered significant amounts of information, or if their prior knowledge/schema isn't sufficiently activated for them to understand it. Some kids just don't know enough about their culture to take advantage of the learning activities.
>
> . . . . For many, the hypercard itself seems motivating. Kids have an urge to finish it. The presence of the tools and capabilities motivates them to try new things and to generate material to use with the tool.

In summary, the teachers used both computers and students' developing expertise in skills and content to extend the instruction in the classroom. The teachers took full advantage of the community members and materials in the classroom to assist with student learning, and they viewed the classroom as a place of multiple zones of proximal development.

Classroom Discourse about Student Design

Throughout the year, students designed many products to reflect their current understandings of reading and social studies information—products like webs of topics, power outlines, issue trees (all tools for organizing information), and plans for screen designs. These "design products" helped students to make their thinking concrete and visible; they made it easier for students to reflect on their understandings. This "objectification of knowledge" allowed students to critique and improve their design products (Harel, 1991; Harel & Papert, 1991; Lehrer et al., 1993; Resnick et al., 1988). It provided many occasions for students to talk about their ideas and critique those of others. Students were continuously sharing ideas, discussing their constructions, and evaluating one another's work.

Designing all types of products—whether plans, charts reflecting the organization of student's topic information, or hypermedia documents—provided objects for class dis-

[7]For more on computers as powerful tools, see Harel and Papert (1991) or Brown and Campione (1994).

cussion and evaluation. Class discourse centered on these student designs; students discussed, argued, and debated the importance of various ideas (e.g., in constructing the assessment rubric at the beginning of a project). Teachers used the design products to stimulate important discussions about similarities and differences in student strategies and for demonstrating that there are multiple approaches to any given problem. One teacher used design products (plan trees and plan sheets for screen designs) so that students could compare their ideas to those of others:

> Bob is having the students share their plan trees [organizing skill] and some of their cards [design skill] on the overhead in class over the next few days. Bob said to me that the "plan trees are the sweetest piece of metacognition you can imagine" and that "the kids really can get inside each others' heads and see how other kids' minds work" by studying each other's trees.

In design, an examination of one's purpose naturally suggests criteria for evaluation of the product (and, perhaps, process) of design (Lehrer et al., 1993). Thus, teachers encouraged students to reflect upon the purpose of the designs in relation to their audience:

> We keep telling them to think of their audience. How will your reader read this? What questions will they have? I think they need to have more of the group critiques and sooner.

Teachers used a group review process to stimulate discourse and to provide students with a real audience for their designs. Students could place themselves in the role of "reader" and provide feedback about the strengths and weaknesses of a hypermedia design.

Teachers used discourse not only to assist students in the appropriation and reflection of design skills, but also as a formative assessment tool. In the following two excerpts, note how the teacher used student discourse to examine changes in students' thinking (in evaluation criteria and in organizing information and designing in hypermedia):

> We critiqued some cards and stacks today. I was totally impressed with the critical standards that kids expressed as they reviewed each other's work—especially on the part of the more reluctant learners.

> I think there is some development of critical standards going on. Jeff and Terri are not happy with how their topic information is playing out on their subtopic plan sheets. Melissa realizes that she needs more info and that her design cards look "stupid" with such small fields and so little information. Trent didn't like how dark his background was and how it seemed to "crowd" the title and field. Kathy couldn't justify her cross-links, tried to and then said, "I better think about it some more." We've been doing better with cross-linking and most of it seems to make sense [kids connect info that is related].

Teachers used student discourse to examine the evolution in students' thinking (i.e., their current standards for work quality or current understandings about design skills).

In summary, discourse centered on student designs and how well they accomplished their purposes. This type of discourse allowed students to reflect on their own design products or process and to compare it to that of others. Moreover, student discussion and feedback were often central to furthering students' understanding of gaps or inadequacies in their knowledge or their designs (Erickson & Lehrer, in press; Lehrer et al., 1994). Finally, teachers used discourse to assess changes in student thinking.

Communal Growth: Sharing and Transforming Ideas

The classroom discourse, particularly the peer critiques, allowed for ideas, concepts and strategies to be "seeded" in the environment (Brown & Campione, 1994; Lehrer, Littlefield, Wottreng, & Youngerman, 1993). According to Brown and Campione (1994), growth takes place when "learners of all ages and levels of expertise and interests seed the environment with ideas and knowledge that are appropriated by different learners at different rates, according to their needs and to the current state of the zones of proximal development in which they are engaged" (p. 237). In this study, teachers and students suggested or developed ideas that were then taken up by other members in the classroom and changed or interpreted in multiple ways. "Participants in the classroom are free to appropriate vocabulary, ideas, methods, etc., that appear initially as part of the shared discourse, and by appropriation, transform these ideas via personal interpretation" (Brown & Campione, 1994, p. 237). Thus, ideas and strategies are "seeded" in the community and "migrate" or are "appropriated" by various other members, who interpret and transform those ideas and strategies to suit their own needs.

In the current study, however, this was not an easy task to accomplish. Some students' notions of "schooling" interfered with the communal sharing of ideas:

> A peripheral issue we have seen as kids shared their trees is one of copying versus collaboration. Many kids from various different cultures [hypermedia projects] are sharing and making use

> of each other's subcategories of the topic, e.g. . . . the Jamaica group sees that the France group has made use of sub-categories like political parties and political problems on their government tree, so they decide to make use of these two sub-categories as well. Some groups think this is copying, where we regard it as learning and sharing together. A few students [cites specific students], tried to copy even the specific details of the sub-categories from another group. He didn't seem to understand that the actual political parties and problems would be different in his culture than in the culture of France. He also didn't seem to see that this *would* be copying because he was not doing his own research nor finding and placing details in their appropriate place on the tree.

Despite these obstacles, teachers reported multiple incidents of how one student's idea or method had been seeded, migrated, or appropriated by others in the classroom. For example, one student (Matt) developed a particular type of link in his hypermedia document during the psychology project. Matt's idea was picked up by several others. The teacher then presented Matt's hypermedia document for review to the class as an example of in-progress work. Eventually the class and teacher evaluated the idea as positive and developed their own term, a "cross-link," to describe that particular type of hypermedia link (one that links across a branch through relation vs. down a subtopic branch). From that point on through the year, the term "cross-link" was appropriated by class members and used in various ways in the designs of hypermedia documents.

Thus, an idea was "seeded" by Matt, migrated to other students and eventually to the teacher, and was appropriated throughout the rest of the community. Students used his idea, which had been elaborated by the class as a whole, in their own hypermedia designs throughout the rest of the year. In addition, the idea was used frequently in providing feedback to peers about hypermedia designs (e.g., "good use of cross-links" or "Amy needs to justify this cross-link because it doesn't make sense to me"). A useful idea by one member was shared with the community and appropriated by others.

Summary of Classroom Development

Teachers reported that the classroom evolved over the school year to become a community of designers. The classroom became a place of multiple zones of proximal development, with people and powerful tools assisting with student learning. Classroom discourse about student design products was central to furthering students' understandings of gaps or inadequacies in knowledge, skills, or design. Furthermore, the classroom became a place of communal sharing, where ideas and strategies were seeded, migrated, and appropriated by others.

Teacher Assessment of Student Learning

What is the evidence to support that this new classroom environment was successful? A final year-end assessment was given during the social studies class, in which students were asked to design a short hypermedia stack.[8] Three days prior to the exam, students chose any topic studied during the year. The intervening three days were for gathering and organizing information. The day of the exam, students had 70 minutes to create a stack on the computer (see Appendix C for directions and criteria for the exam).

Teachers were quite pleased with the final exam results:

> Casey did a stack on study skills and included various tips and formats to help her audience. Mark did a great job on the genealogy of his family and his hyperstack organization reflected that of a family tree . . . 100% of our 125 students completed their stack to the satisfaction of our criteria! Seventeen students stayed after the exam hour, or came after school (on the last day!) to finish [polish] and present their stacks to our faculty panel. This in itself was amazing to us. (Wilhelm, 1995, pp. 39-40)

In addition, the teachers in the study reported that students had learned how to ask questions, find information, and organize and present information to others. Many of the students developed more knowledge or skill in certain aspects of the learning process or in computer skills and had shared that knowledge with others to assist in problem solving (i.e., peer problem solving). The teachers believed that students had demonstrated growth over the year in the cognitive skills of research and design, and they were especially happy that each student ($n = 125$) had completed a final exam:

> Most obviously, all of our students learned how to use, read and design hypermedia documents. . . . Our students are now able to use hypermedia to find information electronically, and to organize and link information, literacy skills that are already

[8]Other data on student learning was collected from various sources. These included student pre- and posttests for several skill areas (question-posing, finding information, and organizing), student journals or "designer diaries" from each hypermedia project, and students' portfolio assessments. However, the reader is reminded that this paper reports only initial qualitative results from teacher conceptions of the study.

> of daily importance to them. They also began to develop critical standards for the relevance, appropriateness and organization of text, and began to construct much more active and participatory roles for themselves as authors and readers. . . . And the students now know how to pursue their own learning. As Jodie told us: "I used to think research was something really hard and I would never want to even get started on it. Now I know I can do it. . . . I know how to do it." And so did our other 124 students, evidenced by the final exam.
>
> Have we ever had 100% enthusiastic participation and completion of final projects before? Never. Have our struggling students, like Jodie, ever been able to choose a topic, find information about it, organize and represent that information to others before, and in a short time? Never and again never. We've discussed at length how it took Jodie a whole school year of hard work to achieve what he did. . . . Was it easy? No. But then the true course of learning never did run smooth. (Wilhelm, 1995, p. 40)

Teachers reported that the student-design curriculum was successful. Not only did all students successfully complete the final exam, but teachers believed that students were appropriating the research and design skills and assisting one another in the learning process.

Concluding Remarks

Student design can be used to reform the nature of learning and instruction in the classroom, simultaneously changing the structure of the curriculum, the roles of teachers and students, and the place of technology and assessment. The teachers in this study attempted to create a classroom community of designers. Although there were challenges to overcoming student and administrative conceptions of "schooling," and other institutional obstacles, the teachers believed that they had made great strides in redesigning learning and instruction toward a community of designers. Students were researching and designing projects that displayed their evolving understanding of social studies and language arts. They were continuously discussing and evaluating one another's work, and teachers used that discourse to examine the evolution of student needs and understandings. The class developed distributed expertise and shared their knowledge and skills to assist community members.

I cannot claim that the results from this study are generalizable to all classrooms. Nor can I claim that this classroom was an ideal community or an ideal reform effort. However, the community of designers did consist of active and enthusiastic student and teacher members. The journal entry below discussed students' enthusiasm for design and computers, and in the same entry, discussed how the teachers themselves had been pushed to think about their "design"—for a better learning environment—with the same effort and enthusiasm:

> *Students.* As the kids get into the computer room, it's clear how engaging the computer is for them. The kids want to fill a card and when they see that they can't there is some motivation to find more information. Plus, most of the kids want to explore the possibilities of the computer.
>
> *Teachers.* Bob and I agree that we have thought and talked about his unit in a depth and with a quality that we have never done before. Why is this? Is it because of the computer? Is it obvious with the computer what kids can and cannot do? Is everything not only more obvious but also accessible to us as teachers because of the cards and the neatness of the stacks versus notebooks in the kids own writing? Is it because we are researching our teaching and the kids' learning?
>
> At any rate, we believe we are dealing with seminal issues of teaching and learning that we have never dealt with before in this way. In the past you developed some assignment sequences designed to support kids in their journey to a particular product. Now we are designing assignments *in medias res* at the point of need and we need to understand the kids, their thinking, their needs, their abilities and lacks at that point. Previously perhaps we often glossed over problems and plowed through with the lesson sequence.
>
> Clearly we are learning more about the kids and each other than we have ever done previously. We notice strengths and weaknesses, capitalize on them, attack them. We notice gaps in their knowledge, in the information they have found. We have to think how to question and encourage them without providing too much support and actually doing the assignment for them.
>
> As we get into the computer room more often . . . we notice how the kids become the real experts. This is of course a goal of ours, to make the students and community members the teachers.

Does the process of research and design itself build or distinguish a community of designers? No. These teachers grappled daily with how to improve instruction in their

classes. Was the success due to teacher reflection? Certainly reflection made teaching more meaningful for these teachers and brought their own domain content "home" to them in a way that they had not known before. Teachers raised questions about their own discipline, made inferences about the learning occurring in this environment, and generated meaningful conclusions about the relationships between their own teaching and student learning.

> It's like you're helping the kids to master the conventions of learning in a domain. And the teacher becomes the learner. That's what's so important for teachers—the whole Vygotskian notion and becoming a learner. (Teacher interview, M, March 6, 1996)

However, I believe that teacher reflection alone was not the key to the success of the school year; rather, there were synergistic changes in the learning environment that led to the building of a community of designers. Some of the key instructional practices that I believe helped to establish such a community were the flexibility and willingness of these teachers to use emergent instruction, which required them to use their teaching strategies in a radically different way. Also, the teachers allowed students time for multiple opportunities to practice the cognitive skills of research and design. The work stations and checksheets these teachers developed moved students through their projects and allowed them to do it at an individualized pace. Teachers continually encouraged and pushed students to become autonomous learners and to ask questions in which they were truly interested. Giving students a voice in establishing the curriculum and assessment required that the teachers give up a measure of control in the classroom and be willing to learn from the students. All of these instructional practices contributed to the student learning that took place in the classroom.

Too often, educational research reports the evidence for student learning without elaboration for teachers on how change can take place in their own classrooms. These initial qualitative analyses give us some ideas about student learning and instructional reform. However, if educational reform is to truly be successful, it must include both studies of student learning and also full descriptions of the evolution in teaching practices.

It takes time to restructure the nature of learning and instruction in a classroom:

> If there is a moral here it is that projects such as this, perhaps research in general, takes time. In school we rush through curricula without giving the students time to plan, set goals, ask questions, have problems, reflect, regroup and attack again. This has taken time but I believe that they have really learned both content area knowledge and learning processes. I think that if we ever want to really revitalize school then we need to reconceive of how we use TIME.

The process of student design-based inquiry requires time and struggle on the part of both teachers and students. In order to create better learning environments in the classroom, both students and teachers need repeated cycles of the design process. Students and teachers need time for cycles of revision—a good designer needs time to revise the design. So the concept of time becomes one critical obstacle to the restructuring of this type of classroom. Nevertheless, after two years of building a community of designers in their classroom, these teachers are just beginning to overcome institutional conceptions of "schooling" and to create a better learning environment in their classrooms.

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Appendix A
Cognitive Components of Hypermedia-Based Design (Lehrer et al., 1994)

Design Component	Primary Skills Involved
PLANNING	
Defining the Nature of the Problem	Question posing
Problem Decomposition	Team collaboration
Project Management	Task and role assignments Developing timelines
TRANSFORMING	
Finding Information	Document search techniques Using keywords in electronic search
Developing New Information	Interviewing Developing questionnaires
Selecting Information	Note taking Summarization Data analysis
Organizing Information	Using multiple organizations for information (outlines, pyramids) Use of database tools Semantic mapping
Representing Information	Segmenting video and sound Interleaving media Graphics production
EVALUATING	
Evaluating the Design	Articulating intentions Public speaking Use of reflection & organizational tools
REVISING	
Revising the Design	Taking design as an object for thought Soliciting peer feedback

Note. For more on this framework, see Lehrer (1993) or Lehrer et al. (1994).

Appendix B
Checksheet for Hypermedia Culture Project

CULTURAL JOURNALISM HYPERCARD PROJECT

Phase 1: Asking Questions/Finding Information

_____ 1. Topic _____
_____ 2. Related Questions
_____ 3. Subtopics
_____ 4. Related Questions (Brainstormed)
_____ 5. Initial Bibliography (Sources) # _____

Phase 2: Organize/Add Information

_____ 1. Initial Plan Tree
_____ 2. Notes on subtopics
_____ 3. Add to Bibliography # _____
_____ 4. Schedule Interview (Person _____ Date_____)
_____ 5. Develop Interview Questions
_____ 6. Conduct Interview
_____ 7. Discuss topics with group

Phase 3: Add/Analyze/Reorganize

_____ 1. Read 2ndary Sources (stories, myths, travel brochures, etc.) Title _____
_____ 2. Revised Plan Tree
_____ 3. List Other Sources of Information
Food
Video
Music
Clothing
Artifacts
_____ 4. Submit Bibliography
_____ 5. Web with crosslinks to group members' topics
_____ 6. Peer Review of Cards

Phase 4: Card/Stack Design

_____ 1. Design Diary
_____ 2. Main Menu Card _____
____ background____ buttons____ links____ pictures/sound
_____ 3. Subtopic #1 Main Menu Card _____
____ text____ background____ buttons____ links____ pictures/sound
_____ 4. Subtopic Supporting Detail _____
____ text____ background____ buttons____ links____ pictures/sound

Appendix C
Instructions and Criteria for Final Exam

HYPERFINAL

The final activity for social studies will be to create a HyperCard stack on a topic from Economics, Political Science, or another topic of your choosing that I approve. The stack you create should be a presentation that explains the topic you have chosen in an interesting and creative way. The better your stack the better your grade. The criteria you must meet are on the other side of this sheet as is the assessment rubric.

Your stack must be completed at the end of the finals period for your class hour. You should begin work on putting together the information and organization for your stack immediately. You will have about 70 minutes to complete your stack the day of the final so be prepared to get it done! Please save any plans you make for the design or organization of your stack and hand them in when you complete your stack.

Possible stack topics:

ECONOMICS:	Supply, Demand, Price (one, all, graphs?)
	Business Enterprises (single, partner, corporation)
	Smart Consumer Steps
	Banks and banking
	Three types of economies
	Four factors of production
POLITICAL SCIENCE:	Types of Governments
	Political Spectrum
	Structure of our Government
	Preamble
	Bill of Rights
	Constitution
	Compare levels of Government
	[Our City] Government
	Do State or Federal Government alone
YOUR OWN IDEA?:	

Continued

CRITERIA FOR HYPERFINAL ASSESSMENT

Name _____
Hour _____
Final Topic _____

Reviewer's Total

Multimedia Card Space Justification and Use	Card space has been thoughtfully used and use of multimedia sources has been considered. Author can justify space use if asked.
Stack Organization and Function	Stack organization follows and easy to use main menu or Table of Contents card. Organization allows the browser to go through the stack in a way that is informative and makes sense.
Information Quality	Text is written in author's own words, is interesting to read, and properly divided.
Spelling Quality	Text is grammatically correct and there are no spelling errors.
Button Quality	Reasons for all links and button names are clear and warranted. Author has used icons and effects that help the browser's understanding of stack organization and/or stack content.
Audience Consideration	An effort has been made throughout the stack to involve the browser.

	Not-yet-competent			Competent			Distinguished		
Multimedia Card Space Justification and Use	1	2	3	4	5	6	7	8	9
Stack Organization and Function	1	2	3	4	5	6	7	8	9
Information Quality	1	2	3	4	5	6	7	8	9
Spelling Quality	1	2	3	4	5	6	7	8	9
Button Quality	1	2	3	4	5	6	7	8	9
Audience Consideration	1	2	3	4	5	6	7	8	9