Imagination, Production, and Collaboration in Project-Based Learning Using Multimedia

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Abstract: There is evidence that technology has played a role in transforming classrooms into places where students are actively constructing knowledge and where teachers structure learning resources to facilitate discovery, problem-solving, and collaboration. In our research, we consider the roles of two processes that use technology to support a project approach to learning using multimedia: creating cycles of student imagination and production and supporting well-developed student collaboration. Our paper examines how technology and pedagogy work together in a fourth-fifth grade classroom taught by the fourth author to support student imagination, production, and collaboration and explores mechanisms that relate these characteristics to the building of student identities as members in a community of practice.

Introduction

There is evidence that technology has played a role in transforming classrooms into places where students are actively constructing knowledge and where teachers structure learning resources to facilitate discovery, problem-solving, and collaboration (Sandholtz, Ringstaff, & Dwyer, 1996; Means & Olson, 1995). To date, however, few teachers are using technology like the World Wide Web to collaborate with others outside their school or to publish their work on-line (Becker, 1999). These findings suggest that there is much to be learned about what conditions are necessary and sufficient for using technology to support students' own knowledge construction.

Since the days of Progressive education, educators have noted the deep learning that can happen when students do long projects together (Kirkpatrick, 1918; Rawcliffe, 1925). Project-based learning, as it is called today, requires students to focus over an extended period of time on the resolution of a real-world problem they have posed (Blumenfeld et al., 1991). Typically, through the course of completing a project, learners use multiple information sources, collaborate with others, and use cognitive tools to plan, conduct, and evaluate their research.

Renewed interest in project-based learning comes at a time when researchers are developing a new theory of learning as *the transformation of participation within communities of practice* (e.g., Lave & Wenger, 1991; Rogoff, 1994). In this theory, learning is defined as a process of participating in and contributing to the activities of one's community (Wenger, 1998). Learning is not separate from activity; instead, through participation, learners come to develop identities as competent members of communities of practice (Lave & Wenger, 1991; Wenger, 1998).

There are many ways that project-based learning might develop a sense of identity and belonging within a community of practice. According to Wenger (1998), there are three modes of belonging to a community of practice: engagement, imagination, and alignment. When students are *engaged* in mutual activity, such as making a presentation, they develop shared histories of learning and relationships as peers and as friends that in turn shape students' identities as different kinds of participants in that activity. Students must *imagine* the broader communities to which their work is connected; that is, the audience for their work together is outside the immediate classroom and shapes how students see the work they are doing (Allen & Pea, 1992; Blumenfeld et al., 1991). Finally, students may *align* themselves with broader activities or initiatives, when their learning connects to what other students in other schools are learning or to what professionals are learning and doing in their own communities of practice.

Multimedia technology is a potentially powerful support for learning to become a competent member of a community of practice (see Erickson & Lehrer, 1998). When students produce multimedia

products, they make public artifacts that connect them to communities beyond the classroom. The prospect of having their work published on the Web or shared with the community at a public showing can engage students' identities and excitement about learning and motivate high-quality work. Technology can also support the development of meaningful peer collaboration in project-based learning by allowing students to recognize diverse skills and competencies of peers (compare Cohen & Scardamalia, 1998).

Whether the potentials of project-based learning using multimedia are realized, of course depends on the skillful organization of learning resources. In this paper, we describe how project-based learning using multimedia unfolds in a particularly successful classroom. Our purpose is to help teachers design project-based learning opportunities with multimedia by showing how a collaborative classroom community developed through the course of a project.

The Current Study

The classroom we study here is part of an initiative called Challenge 2000 Multimedia Project, a project funded through a Department of Education Technology Innovation Challenge Grant. Project staff and teachers in the project have developed a model of project-based learning using multimedia in collaboration with researchers from the Institute for Research on Learning (IRL). This model incorporates dimensions that have traditionally been associated with a "project approach," such as having a real-world connection, but adds the practice of producing final products in a multimedia format.

The project identified seven characteristics as central to the model:

- Anchored in core curriculum; multidisciplinary
- Involves students in sustained effort over time
- Involves student decision-making
- Collaborative
- Has a clear real-world connection
- Systematic assessment throughout the project
- Takes advantage of multimedia as a communication tool.

Multimedia technologies are to be used as tools in planning, developing, and presenting projects. It is believed that the power of multimedia lies in the extent to which it is integrated within the goals of the project and ongoing curriculum.

Results of observational studies of the Multimedia Project over two years (Means & Golan, 1998; Penuel & Means, 1999) suggest that the model is quite successful in transforming teaching and learning. Students in project classrooms were engaged in significantly longer activities within the single class periods observed than students in non-technology-using classrooms within the same school. Moreover, project classroom students were more likely to be engaged in long-term activities—that is, activities that spanned more than a week of class time—than their counterparts in the comparison classrooms. Students were also engaged in more of what might be called *cognitive activities of design.* In other words, they were engaged in higher-level cognitive activities characteristic of multimedia design as described by Lehrer (1993): deciding on the structure of a presentation; creating multiple representations, models, and analogies; arguing about or evaluating information; thinking about one's audience; and revising or editing work. Students in Multimedia Project classrooms were also more likely than comparison students to spend time engaged in small-group collaboration (Penuel & Means, 1999).

These observed differences in the kinds of activities students engage in, the way students work together, and the extent to which students engage in reflective monitoring of their own learning point to the promise of project-based learning using multimedia (PBL+MM) for making a difference in teaching and learning. Unfortunately, the observational data tell us little about how projects were carried out in the classroom. To provide more insight into the processes involved in successful project-based learning, we examine how one teacher implemented the Challenge 2000 model in his classroom.

In our study, we draw on observational, video, and interview data collected by both SRI and IRL over the course of the project in a fourth-fifth grade classroom taught by the fourth author (Jump). We provide a rich description here of what we have observed as researchers (Penuel, Cole, and Korbak) and as facilitators (Jump) of project-based learning that would enable researchers and teachers to understand some of the reasons why project-based classrooms differ from comparison classrooms in the ways described above.

Underlying Processes Of PBL+MM: A Case Study

In this section, we review the roles of two processes that support a project-based approach to learning supported by multimedia in one elementary school classroom:

- Students' engaging in an upward spiral of *imagination and production*
- Students' engaging in increasingly well-developed *collaboration*

We consider how technology and pedagogy can work together to support imagination and collaboration, and we explore mechanisms that relate these two characteristics to increased student engagement and excitement.

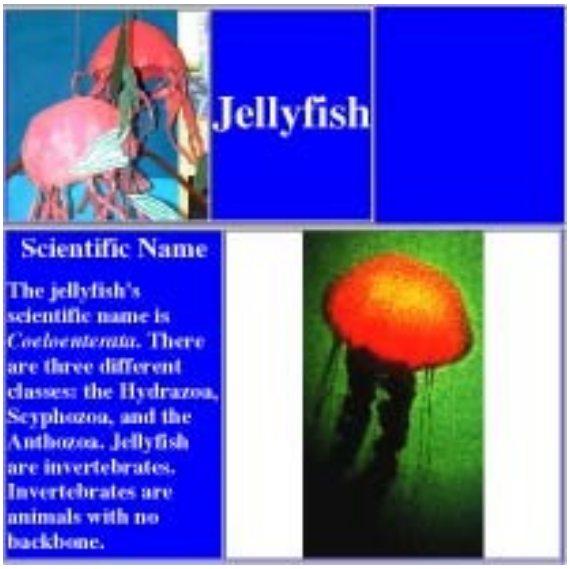
The Habitat Project at Ohlone Elementary

The fourth author teaches a mixed class of fourth and fifth graders at Ohlone Elementary School in Palo Alto, California. The Habitat project involved students in creating hands-on habitat dioramas and then multimedia versions of those same habitats. The class's school year starts with a field trip to the California Academy of Sciences, where Ohlone students view the Wild California dioramas and do research in the Biodiversity Center. In the third week of school, the class stays for three days and two nights at the Clem Miller Environmental Education Center at Point Reyes National Seashore. Students choose an animal to study that is native to California and lives in one of the habitats nearby Point Reyes. Using information from the Academy of Sciences, the library, and the Internet, students construct a papier mâche model of their animal, form a habitat group with other students whose animals live in the same habitat, and construct a diorama with butcher paper, construction paper, paint, and dried plants. Into this diorama, they place their animals along with interpretive posters detailing diet, habits, range, and other information about their animal. The class finishes the project by inviting the school in for docent-led tours. Figure 1 shows one diorama.

Figure 1
Diorama of an Ocean Habitat

The teacher and his students decided to revisit these dioramas when they did their multimedia projects. In the way that video can preserve a theatrical performance, the class decided that World Wide Web pages could allow students to have a wider audience for their work. Web pages would in effect create an archive that would allow others to see what students had learned beyond the short period of time the models and murals in the classroom could be displayed. Using material already created meant that students could build on work they had already done, deepen and expand their research, and learn a new method for presentation of information. Groups were again divided by habitat or, in some cases by species, such as *birds of prey*. They worked together to create a Web-based version of their habitats, including the best of their dioramas plus additional pictures and text they thought were appropriate for Web-based presentation. Figure 2 shows one student's *Jellyfish* page.

Figure 2
Jellyfish Page



Defining the Project through Imagination and Production

Wenger (1998) defines *imagination* as the process of projecting through time and space. Imagination had two roles in the project, one conceptual and the other practical. Conceptually, the process of imagining others outside the classroom viewing their habitat pages gave meaning to the project and provided a real audience. Practically, projecting from their dioramas to a not-yet-existing Web page organized their efforts to expand their research, scan images, and the like.

The process of imagining an audience wove its way into the most mundane of tasks. For example, one day the class was discussing why they should preview their pages in a browser:

> Jump: What's going to happen when you do your Web page? Where are people going to look at it?
> Student: On the Internet.
> Jump: On what machine? *Their* computer, not yours.

Students took the issue of the audience up many times:

> Arthur: Only a few people saw their work. Putting their work on the Internet would allow more people to see their work.
>
> Donna: On the Internet everybody in the world could have access to it.

This idea became more and more elaborated as the project went on. At first, students talked about others' seeing their work in general. But as they discussed specific Web pages during assessment activities, imagining the audience became a way to evaluate many design and content choices. For example, a student explained that a photo caption should have more information because the reader might not know as much as the writer:

> Helen: And maybe they could have had a little more writing in terms of, they just had, see, if you look down there, it was, 'This is Room 15 at the lighthouse' I think that was. It could have been, 'This lighthouse is in Point Reyes', and just give that little more specific information, because people might not know what room 15 you're talking about.

Here the class is discussing the benefits and drawbacks of using strong colors:

> Frances: I think the downside is, it sort of puts you on the color more than everything else.
> Teacher: The color can overwhelm the content.
> Rob: It makes some people nauseous.
> Teacher: People have different reactions to colors.

Imagination, coupled with students' own Internet experiences, helped give the project meaning and audience. Imagination and production were both necessary to give it substance and shape.

It is difficult to say where the multimedia project begins, because there were so many overlapping activities. These activities evolved on a daily basis because the project was a new experience for teacher and students and project plans were adapted as circumstance and experience demanded. For example, much of the equipment needed for the project was acquired through a grant from the Challenge project. When there were delays in receiving the equipment, planned activities had to be re-ordered. Students' skill in using the multimedia equipment varied, and there was no way to predict in advance how much time would be required.

Another activity involved a visit from a professional Web page designer who critiqued a page with the students. This activity was chosen so that students would see that their Web page products could be objectively evaluated and that their products were connected with the work done by people in real world settings. As a follow-up activity, two girls created a sample Web page for the class to critique. Students were learning that decisions for Web pages should not be random but should be based on standards of what makes a good page. The class also developed a rubric for evaluating Web pages that used "kid language". This rubric was based on one provided by the Challenge project which is intended for adults and uses vocabulary beyond the understanding of elementary school studentsIt was believed that students could do a better job creating their Web site if they understood how others would evaluate it. In order to prepare for creating individual components of the project Web site, students created storyboards on index cards. These index cards were intended to be drafts showing what each Web page on the project site would look like and which pages would be connected to each other.

During these activities, students expressed what they were doing with varying clarity. "We're sizing pictures, because Otak told us to. I'm not sure what he's going to use them for," explained one girl. But each act of production, and each imagination-powered discussion, served to further shape and clarify the project, so that students' competence continually spiraled upward. For example, early in the project, students drew storyboards that looked like presentations created in the multimedia software program HyperStudio, because that was what they had done before. Once they had a chance to see and work with HTML tables, their ideas for what was practical and attractive on a Web page changed. For example, one student, Allen, wanted to incorporate a quiz in the section of the Web site that he was working on. He was able to construct the quiz but then faced the task of making it an interactive piece on the World Wide Web. He decided to take the answers to his quiz and include them as a set of facts instead. We asked Allen why he had changed his "quiz" to a simple set of facts. He explained (correctly) that it would have been much too hard to implement the quiz on the Web. This example supports the idea that students do not need to develop technical skills before they can address content; the process of learning to use multimedia technology can be carried out at the same time that students are developing the content of their projects.

Assessment and Bootstrapping: Supporting Cycles of Imagination and Production

Cycles of imagination and production were supported in class in at least two important ways: through continuous informal assessment and through bootstrapping student skill-building in using multimedia.

*Assessment***.** Assessment was informal and took many forms. Early in the multimedia project, students took the existing Challenge 2000 Multimedia Rubric and rewrote it in "kid language." This process gave them an opportunity to discuss what made a project good. As the project progressed, class sessions were held in which students critiqued each other's works in progress. Assessment supported both imagination and production, in at least four ways. First, assessment helped define the project as something that required design decisions; simply scanning some images and using any random color would cause problems. Second, assessment discussions gave students a way to interact with models so that the discussions were more effective in shaping production. Third, assessment events reminded students that they already knew a lot about organizing and presenting information. They could see how their expertise applied in the new medium. Finally, assessment helped students distil essential elements of the project. It had to have good pictures, different kinds of pictures, eye-catching colors, and lots of information. It should be organized and should keep the audience interested. Each of these was elaborated through specific exemplars.

Bootstrapping. Bootstrapping refers to the fact that students began basic production activities before the project was completely defined. It was not necessary for storyboards or even research to be

complete before students started scanning images and making HTML tables. In fact, these activities helped students understand the project much better than they would have with the most exacting planning. Bootstrapping enabled students to imagine accurately and thus produce more efficiently.

Effects of Supporting Imagination and Production

After a period of work that looked somewhat random and tentative, students were able to produce Web pages in a few weeks, even though they could work only three at a time on the computers. The pages conformed to what the students had identified as important aspects of quality: lots of information; good pictures; intentional use of color; and simple, clear navigation. Students were able to create efficient production systems and get the work done. Students had two chances to interpret the task of making a Web-based version of their dioramas: first when they made their index card storyboards and again when they made their Web pages. We compared eight randomly selected storyboards, which students had made before all the assessment and bootstrapping activities, with the final Web pages. Almost all (seven) of the Web pages had more information than the storyboards. All had a simpler organization. Many (five) had additional pictures not in the dioramas, and all had more pictures than in their storyboards. Three students addressed the audience directly in some way, such as explaining in a caption the purpose of a drawing.

Developing Collaboration among Students

Collaboration is a primary motivation for engaging with schools at Ohlone. Indeed, this class has an extremely strong collaboration ethic. By fourth and fifth grade, the students we observed automatically organized activities collaboratively, and used a variety of strategies to include everyone in the work and make decisions fairly. Collaboration was one way that students aligned with the broader school ethic of inclusiveness. The school stresses inclusion everywhere from the playground to the classroom. Collaboration also became central to what it meant to do multimedia:

> Interviewer: What do you think of when you hear "multimedia"?
>
> Jamie: Collaborating with other people and tools to make a project.
>
> Mark: A big project with other people and collaborating to make one big product.
>
> Stephanie: teamwork; trying to say, "Okay, that's a good idea"; thinking of other people; not blurting out your ideas.

What was the role of collaboration in making the Habitat project successful? The collaborative structure of the activities had three important effects on classroom processes. First, it provided multiple entry points for students with different skills and strengths to become involved. Second, it allowed students to define roles for themselves over time. Third, it made it possible to get the project done in an efficient and timely way.

Multiple Entry Points

The Chaparral group was one of the largest Habitat groups, with seven students. During the project, we saw several of them take an important role at different times. Dominique facilitated a discussion on translating a rubric to "kid language." Ian was central in creating the rubric, and one day he helped organize research in the library. Laurie helped create the model Web page for the class to critique, and over the course of the project became one of the more technically adept students. Emily guided less-technical students through the process of creating their HTML tables. Finally, every member of the group took responsibility for his or her animal page as the content expert: designing the page, finding and selecting photos and drawings, and composing text. The project was complex enough so that students could come in and out of central roles according to what they could authentically contribute.

Ongoing Definition of Roles

The Habitat multimedia project was not unique in allowing students to take on roles. However, it was unusual in that it required so much of so many different kinds of work that students had to find a way to divide responsibilities or the project would never have been finished. This was most striking for students who became computer experts. Computer experts sat with content experts as they created their page, working through the steps necessary to create the page with Adobe Photoshop and Claris Home Page. Content experts made design and content decisions.

The students below are engaged in the process described above. One of the girls is the computer expert, and the other is making choices about her page.

Computer Expert: Do you want this place [referring to a spot on the Web page they have on the computer screen] to be like a certain color?

Content Expert: Um, no.

Computer Expert: You just want it white. You want the text to be a certain color?

Computer Expert: And do you want the, the second picture here or…

Content Expert: [points to where she wants it on screen] Here.

Computer Expert: Okay.

(They continue with decisions about text color and format.)

Having a central role was extremely important and, in some cases, identity changing, as Michael explained at the end of the project:

I think on a scale of 1 to 10 this was an 11, of the projects I've ever done. 'Cause I've never really done any big projects in my class in second and third grade. I wasn't the best student; I didn't get all of my work done…And then I came to fourth grade not knowing if I would do good at all, and Otak put me on a lot of projects. I think this is one of the best projects I've ever done or worked on, with a lot of great people to work with. And I think it's going to look great.

Getting It Done

The class had access to a small number of computers. The project had to be finished by the upcoming Multimedia Fair. Meanwhile, there was the rest of the curriculum to implement, so only a few students at a time could work on the Habitat project while other work was going on. Most of the time, they had to be able to work autonomously while the teacher was otherwise engaged. With approximately 35 separate pages to design, there was a lot to do. The "computer expert and content expert" organization evolved, in which the computer experts managed the technology and also to some extent the work, sending for students whose turn it was to add their content. This process went amazingly smoothly, especially toward the end of the project. The class was in production mode, and the work times were extremely focused and efficient, with most pages completed in about a half hour.

Video Debriefing and Culture-Building: Supporting Collaboration

There are two processes that helped build the kind of collaboration that was observed among students. First, an innovative approach to assessing collaboration was used, incorporating videotapes of students working together as a tool. Collaboration was also supported by the active building of a school-wide culture of collaboration at Ohlone.

Video debriefing. The idea of a video "debriefing" from theater work he had done before becoming a teacher. Improvisational actors often use the frame of "helping" and "hindering" as a guide to playing a character. Some characters help the action by supporting the goals of the other actors, while others hinder or block the other actors' goals. In class, students were asked to identify helping and hindering behaviors with respect to how they were working together on the project.

The class work on the project began by leading a discussion about the learning goals for the project and asked students to brainstorm ideas about the types of behavior that would help to reach those goals. During each hour of student work, short video segments were recorded showing students doing whatever they were doing. These would include as many different kinds of potentially helping and hindering behaviors as possible.

Either at the end of the session or at the beginning of the next class period, the class would watch the video. Jump would point out specific behaviors that he wanted students to learn from, and he solicited student comments about which of the behaviors they had seen helped and which ones hindered the class in meeting its goals. Importantly, the discussion was focused about describing student *actions*, rather than characterizing *people* as helping or hindering.

Culture-building within Ohlone. Students in the class came to their multimedia projects with a lot of experience in collaborative learning. They brought a repertoire of skills for working together—including planning work together, negotiating roles, and facilitating the completion of complex tasks in groups—to this particular project. It would therefore be wrong to suggest that the multimedia project itself, or even the video debriefing caused the development of meaningful collaboration. Rather, students were prepared for working together on this project through their ongoing participation in multiple collaborative projects and learning opportunities across the school.

Effects of Supporting Collaboration

The video debriefing process helped students stay away from blaming people for problems and focus more on the kinds of things students were doing that were hindering the work. Over time, moreover, the video became less intrusive, and students became less focused on the fact that they were appearing on screen and more focused on the task of identifying helping and hindering behavior. Finally, there was less need for external regulation of student behavior: students tended to regulate their own actions more effectively with the video debriefing than without it.

The fact that throughout the school, students are encouraged to work together on projects across the curriculum means that students engage their collaboration skills readily and consistently when confronted with new tasks. Even when assignments do not have the same structure as the Habitat project, students easily slipped into working together to accomplish the assignment, allowing different leadership roles to emerge as the project unfolds and reflecting on what is helping or hindering their work together. Initially, students brought to the project a sense that the quality of collaboration was dependent on involving everybody and minimizing disagreements. In this respect, their earlier school experiences in Ohlone had prepared them to *value* collaboration as a process of including others and resolving disputes harmoniously. As the project unfolded, students developed a different notion of collaboration, focused on the appropriate use of individual strengths to accomplish a group task.

Implications for Teaching and Learning

One of the key reasons why multimedia projects may be so successful is that they allow students to feel that what they are doing is "real" and requires their active participation to be successful. According to Wenger (1998), the work of *imagination* is in part to locate engagement "in broader systems in time and space, conceiving of the multiple constellations that are contexts for our practices" (p. 185). In this sense, one key to the success of the project was the extent to which the Web pages the students designed helped students situate their work in a broader, more "real" community than just their local school. Providing a real audience for students is critical if projects are to be as successful as this one was in engaging students and helping them imagine their projects as something different than a typical classroom assignment.

Differentiation of roles is often cited as a tool in collaboration (but see Wilcox, Williams, & Reutzel, 1997), but what was particularly successful in this classroom was the extent to which roles were not pre-established but emerged in the context of group work. The roles, moreover, were project-specific and organized about the specific learning goals set by the teacher. The teacher established the learning goals, continually revisiting those goals in light of the quality of student work and collaboration through the assessment practices and video debriefing, but he also allowed the students to draw on their considerable skill and experience in working together to define roles as they proceeded.

Not only did students come to engage in a more focused an excited way in the classroom as the project progressed, but also their classroom identities were transformed in the process. First, through the expanding cycles of production and imagination, students developed as sense of competence as "good-at-projects," and students came to recognize classroom leaders as those who had particular skill in completing projects. The rubric students developed and used helped to keep a focus on the different aspects of what would constitute a "good" project, allowing students to develop multiple meanings for what it might mean to be "good" at a project (e.g., good at design or good at content). The process of collaboration helped students develop a sense of themselves in relation to others, helping to maintain students' relationships as friends to each other and allowing different student competencies to be recognized and valued by others.

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