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ABSTRACT

This study examines a 3-month software design activity in which mixed teams of girls and boys designed and implemented multimedia resources. Mixed-gender teams of fifth and sixth graders used Logo MicroWorlds in their classroom to design multimedia encyclopedias about their astronomy unit for use by younger children. In this context, students' science and programming was assessed, as well as the status of girls in these mixed-gender teams--their status positions at the outset (as defined by their levels of access to programming and other technologies in use), the change most girls experienced in going from low-status to high-status designers, and the means by which these changes were accomplished. In examining this last factor, several support structures that emerged over the course of two projects to address girls' needs are outlined. The paper concludes with a discussion of the implications of findings for developing and maintaining gender equity in educational technology use. (Author/AEF)

Paper Session

Give Girls Some Space: Gender Equity in Collaborative Technology Activities

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Abstract

Equitable computer collaborations in mixed-gender teams have been a pressing issue for many years. While some have argued for creating single-gender teams or girls-only computer activities, the current study examines a three-month, software design activity in which mixed teams of girls and boys (10–12 years old) designed and implemented multimedia astronomy resources for younger students. In this context, we assessed not only the students' science and programming learning but also how the status of girls was defined by the students themselves at the project outset and how it changed throughout the project duration. We found that the documented positive change in girls' status was impacted by social and physical work arrangements but also resulted in less flexible planning conceptions. We discuss the implications of these results in regard to issues surrounding the development and maintenance of gender equity in computer use.

As recent research has shown, the road toward becoming technologically literate and scientifically competent has been a "leaking pipeline" for girls and women in particular, from the elementary schools where girls feel disenfranchised in science and technology to universities where fewer female students choose science and engineering majors (Camp, 1997). A variety of explanations has been offered for this trend, ranging from different attitudes toward computers (Shashaani, 1994) and different levels of participation in computer and science courses (Chen, 1985; Linn, 1985) to cultural and social conditions found in the respective domains (Sadker & Sadker, 1994) and different representations of women in media publications (Heller, Brade, & Branz, 1994). While each of these variables alone or in combination has an impact on situating girls' interactions with computers, we examined more closely girls' access to computer resources in classroom activities. With the increasing use of computers in classrooms, there remains the issue of whether all students participate equally and receive equal benefits. We were particularly interested in identifying the kind of activities and support structures that can be used in helping girls break down barriers to technological access and gain expertise in a variety of mixed-gender settings.

Toward that end, we investigated students' activities and collaborations during a three-month computer project. In this project mixed-gender teams of fifth and sixth graders used Logo MicroWorlds in their classroom to design multimedia encyclopedias about their astronomy unit for use by younger children. We paid particular attention to the status of girls in these mixed-gender teams—their status positions at the outset (as defined by their levels of access to programming and other technologies in use), the change most girls experienced in going from low-status to high-status designers, and the means by which these changes were accomplished. In examining this last factor, we outline several support structures that emerged over the course of two projects to address girls' needs. Finally, we conclude this paper with a discussion of the implications of our findings for developing and maintaining gender equity in educational technology use.

Theoretical Background

Many girls are not receiving the same kinds of opportunities to become technologically skilled as boys are (e.g., Wellesley College Center for Research on Women, 1994). Boys develop alliances with computers largely due to their extensive out-of-school computer experiences. Boys are more likely to attend summer computer camps than girls, more boys than girls have their own computers at home, boys play more video and computer games than girls do, and boys are more likely than girls to see themselves depicted (as male main characters) in these games (Sadker & Sadker, 1994). These factors relating to amount of experience with computers have a significant effect on students' attitudes and perceptions. In a survey of high school students, boys had higher ratings than girls on all of the following: perceived competence with computers, positive attitudes toward computers, and perceived utility value of computers (Shashaani, 1994).

Gender differences also arise when boys and girls use computers in the school context, even though so-called "equal opportunities" may be presented. Studies of computer use at school have found that when computers are used during class time, boys are more aggressive at grabbing computer space, often refusing to share with girls (Sadker & Sadker, 1984). In observations of student dyads working on the same computer, boys were shown to use more aggressive tactics to gain control, such as grabbing the mouse and pulling it away from their partner. Girls, on the other hand, used more "noncontact" methods, such as verbal requests. Notably, when mixed-gender dyads were observed, the girls' requests were often ignored

(Inkpen, Booth, & Klawe, 1991). Boys also are more likely to initiate and maintain control of school computers during nonclassroom hours, such as lunch time and before or after school (Canada & Brusca, 1991).

These research findings can prove disheartening to those interested in providing equitable and empowering technology experiences for children of *both* genders. Studies have shown, however, that when girls have as much exposure or interactions with computers as boys do, gender differences tend to disappear (Linn, 1985). In learning situations in which children can work on computers at their own pace and engage with tasks according to their interests and styles, girls tend to be as proficient as boys in programming (Harel, 1991; Kafai, 1995). Giving opportunities for access thus seems to be a crucial aspect in overcoming the widespread gender differences as well as finding computational activities that appeal to both genders (Spertus, 1991). Access, however, is often hard to come by—both in activities with computers and those without.

Even when computers are not involved, putting students in mixed-gender teams for collaborative work in academic subjects can result in very different experiences for boys and girls. Research shows that gender is often a strong predictor of status in heterogeneous groups; thus, girls' contributions to group work end up being less valued than boys' (Cohen, 1994). When dissension occurs in mixed-gender groups, boys' opinions are also more likely to win out over girls'. These gendered interaction patterns sometimes have consequences for girls' ability to make the most out of collaborative work, as evidenced by subsequent knowledge assessments (Webb, 1984). Even when academic achievement is not affected by these differences in interaction, girls' self-esteem and interest in the subjects in question may suffer (Wilkinson, Lindow, & Chiang, 1985).

In attempting to ensure that girls will have the technological opportunities they need, some researchers and practitioners have taken the approach of providing "female only" environments. Whether this means pro-active technology intervention programs that are exclusively for girls (Martin & Heller, 1994) or forming single-gender collaborative groups in after-school computer clubs (Wood, 1996), the assumption in most cases is that girls will have a more positive experience in the absence of male computer users. While these programs represent important steps in introducing girls to technological activities, we find that eventually girls will have to learn how to negotiate access in mixed-gender settings. Our aim in this project was to find out how girls (and boys) might react to the challenge of working with programming technology in mixed-gender groups in a classroom setting. Based on the existing research, we anticipated that at the outset of the project girls would occupy lower status positions in their groups; however, we hoped that through careful attention to addressing their needs in the project, girls' status would change. Our primary goal, then, was to investigate how we as researchers and project directors could help girls rise to the challenge and succeed.

Research Participants, Context, and Methods

The software project from which our gender study comes is based on the model of "learning through design," in which students simultaneously learn new information and design a relevant product reflecting their knowledge (Harel, 1991; Harel & Papert, 1990; Kafai, 1995). The project took place in an urban elementary school that functions as the laboratory school site for UCLA. The participating classroom was equipped with seven computers; one of each was set up as a workstation for the seven table clusters. An additional seven computers were in an adjacent room and were mostly used for related Internet searches.

An integrated class of 26 fifth- and sixth-grade students participated in this project. There were 10 girls and 16 boys of mixed ethnic background (19 Caucasian, 2 Hispanic, 3 African-American, 2 Asian) ranging between 10 and 12 years of age. With the exception of 10 students—8 had participated in another design project the previous year and 2 knew programming from home—none of the other students had any programming experience before the start of the project. All the students had used computers in school and were familiar with word-processing packages, graphics software, *Grolier's Multimedia Encyclopedia*, and searches on the World Wide Web.

Heterogeneous groups of three to four students each were arranged in seven teams according to the following criteria: one "experienced" designer (who had participated in the previous design project), mixed gender, and different academic skill levels. One week before the start of the project, students were given an introduction to the main features of the MicroWorlds Logo programming environment. The assignment was to build an interactive multimedia resource about astronomy for younger students. Over the course of several months students created their own research questions about astronomy, researched these questions using various sources, and represented their findings in a group software product. Students worked three to four hours per week on the project for a period of three months, spending 46 hours in total, of which 23 hours were dedicated to programming. Science instruction and programming time were combined. Groups were videotaped regularly and their activities were documented via fieldnotes on a daily basis. Criteria for determining boys' and girls' status roles in collaborative teams were developed through ethnographic observations.

Defining Status

In most previous studies of collaboration, groups of students are engaged in a single task, such as solving a math problem or writing a story. In the learning-through-design environment, however, the final task of making a multimedia encyclopedia requires many different kinds of activities in order to be accomplished: research, drawing or planning screens on paper, graphic art, and programming. Observations led to the conclusion that students' own conceptions of status in this more complex environment were based on what activities were most desirable and who had the most opportunity to do them (see Table 1).

Table 1. Activity status

High-Status Activities	Medium-Status Activities	Low-Status Activities
MicroWorlds work	Grolier's research	Book Corner research
Internet research	Asimov CDs research	Drawing screens on paper
Leading software demo	Word processing	Team progress reports
Consulting	Sidelining	Doing nothing

In actuality, students managed to divide labor in their groups into many more individual tasks than the four mentioned above: research, planning screens, graphic art, and programming (see Table 1). In fact, students collapsed the tasks of programming and graphic art into one category, known as "MicroWorlds," such that anything done in that environment was considered high status. A related activity also having high status was that of "consulting," meaning that once a student (often male) had developed expertise in a certain area of programming, his or her help was often solicited by other groups. This "expert" usually also led the discussion of his or her group's software at the first several demo sessions, in which groups shared their developing products with one another. Students divided the activity of content research into multiple categories, with research on the Internet being the most prestigious, followed by research using available computer software (*Grolier's Multimedia Encyclopedia*) and CD-ROMs (*Isaac Asimov's Universe series*), and book research having the least desirability.

The remainder of the ways in which labor was divided in the design project carried lower status in students' design teams. Only two of the other activities, both of which had medium status, afforded any access to the computer at all. Word processing developed as a task that would be performed by someone who had accumulated information about astronomy from research but was denied access to the programming environment. These students would type up summaries of what they had found out about particular topics in a word-processing file, which could then be imported into MicroWorlds by another team member who was programming screens for the multimedia encyclopedia. "Sidelining" was defined as sitting next to another team member who was programming. The "sideliner" watched and occasionally provided design suggestions or help with debugging but rarely touched the keyboard or the mouse. The remaining low-status activities afforded no computer access and were considered relatively dull by almost all the students in the class, both those who avoided doing them and those who did them by default.

For data analysis, students received status codes based on whether or not they typically engaged in high-, medium-, or low-status activities. Students received a 3 for high status, a 2 for medium status, and a 1 for low status. Fieldnotes and videotapes of group interaction were coded for each student's status level, and students received a single status score for two time segments during the project. The first time point (T1) was after the first three weeks of the project, and second time point (T2) was approximately two weeks before the end of the project. We then conducted analyses to determine what factors predicted status at T1, predictive factors at T2, and change in status levels over time.

Results

Learning assessments. In terms of the effectiveness of the overall intervention, we found that the design project was successful as a vehicle for both science learning and Logo programming development. All students were administered pretests and posttests in astronomy and Logo. Our preliminary analysis showed significant differences for the pretests and posttests in students' understanding of Logo ($p < 0.05$) and astronomy ($p < 0.05$). No gender differences were found in student pre/post gain scores in either astronomy or Logo. While we have not included a comparative component in our research, we know from prior studies that included comparative assessments to students that learned programming by other pedagogical means (Harel, 1991, Kafai, 1995) that software design was a more effective way of learning subject matter and Logo programming.

Gender and Status. The factors of age, gender, previous design/programming experience, and academic achievement were analyzed via multiple regression for their predictive value for status at T1. A composite of two factors was significant, that of classroom leadership and gender ($p < .001$). These two variables were confounded, however, because all but two of the nine students nominated as classroom leaders by their teacher were male. Statistical results confirmed what we had observed during student work time: a significant number of girls were engaged in low-status activities that afforded little access to new technologies.

Students' status levels did not stay the same throughout the project. At T2, status was measured again and found to be not significantly correlated with status at T1 (Pearson correlation = .1880, $p > .100$). Furthermore, the composite of leadership and gender was not significant as a predictor of status at T2 ($p > .05$). Girls' status, in particular, changed greatly from T1 to T2 (see Figure 1). While at the beginning of the project all but three girls had low-status group roles affording very little computer access, at T2 the majority of girls were engaged in high-status activities. Girls were seen taking more leadership roles in demo sessions and programming on the computer more frequently. It appears that the software design project provided girls an opportunity to change the pattern typical of girls in mixed-gender teams—remaining low status throughout the duration of group projects.

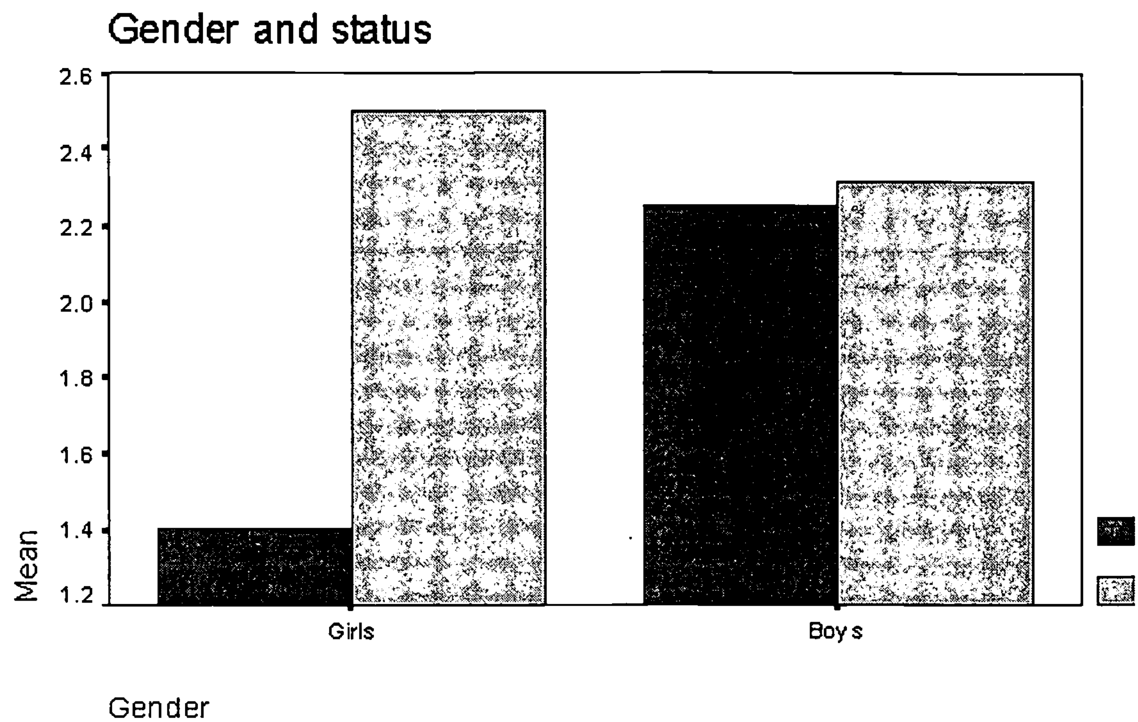

Figure 1. Gender and status.

Analysis: Give Girls Some Space

So how did these status changes for girls take place? We observed that status changes began gradually occurring as features were added to the project to address girls' emergent needs. We refer to the process of changing the classroom design studio to reflect diverse needs as "creating spaces" on the social and physical planes of the environment. Within these "spaces," girls (and some boys as well) found contexts that were more compatible with their own ways of interacting, working, and thinking than they had encountered in the initial structure of the design environment. In this next section, we describe the "spaces" that were created, and we discuss how they emerged and their subsequent effects on girls' attitudes and behavior in the design project.

Social Space

Research shows that when mixed-gender groups of students engage in collaborative work with advanced technology, students' effort and interest in different aspects of the project tend to fall out along gender lines. Fredricks, Blumenfeld, and Bass (1997) found that while boys in mixed-gender groups invested more energy in mastering technology, girls were more concerned with orchestrating and organizing their groups. In our project, we found this to be initially the case as well; implications of these gender differences for group communication and conflict resolution became evident as the project progressed.

Early in the design project, the task of organizing and reporting on group progress toward product completion was assumed by girls. This task required talking to everyone in the group about what activities they were engaged in and what their goals and plans were. Girls experienced frustration with this activity, due to the fact that many boys did not want to sit down and discuss anything if it took time away from programming. Girls were also concerned with resolving interpersonal problems within teams right away when they arose, whereas boys focused more on getting computer work finished and would keep right on working and ignore problems that came up, even to the extent of not listening to girls when they attempted to talk about these issues. After observing these interactions for several weeks, we saw a need for a specific "space" on the social plane of the design project that could be an appropriate time and place to air personal conflicts and frustrations in a safe and mediated environment.

Our solution was to create group meetings that were mediated by either the classroom teacher or a researcher. These meetings occurred about once every 10 days. Students were told that each person in the group would have a chance to say what was bothering them and then the whole group would address each issue. We found that while we had initially instituted the sessions to ensure that girls would be listened to by boys in airing their complaints, boys also had many issues they needed to work out, but which they hadn't been addressing during computer work time. (Issues the boys were upset about concerned Internet use for legitimate research versus "surfing" for fun, ownership and piracy of ideas, and accusations of "goofing off.") All groups came to some resolutions through these discussions, and most boys and girls subsequently reported that there were fewer conflicts in their groups as a result of the meetings. Thus, although the "social space" of group meeting time was initially created as a place to address girls' concerns, boys benefited from this development as well.

Physical Space

Canada and Brusca (1991) argue that girls' initial lack of enthusiasm in computer-based environments may be partially attributable to the physical structure of the computing facilities themselves. Since the majority of computer environments take the form of individually segregated workstations, this arrangement tends not to appeal to girls and their preferences for a work style characterized by more social networking. In our design the group workstations were spread throughout the classroom, making it difficult for students in different teams to communicate with one another without leaving their seats. At the beginning of the project the computers in the adjacent lab were designated for Internet searches and other research only; students were supposed to program in MicroWorlds at their groups' workstations inside the classroom. We found that when girls had opportunities to work at the classroom computer workstations, they often got much less accomplished than boys did in the same amount of time due to frequently showing off their new work to friends and getting up to view one another's screens. (In fact, one of the boys' chief complaints during the group meetings was that girls did not make "good" use of their computer time when they had it.) Thus, the arrangement of physical space in the classroom seemed to be holding girls back—until they changed it.

During the fifth week of the project, a few girls began "breaking the rules" and appropriating the laboratory computers for MicroWorlds work. The physical arrangement of the lab was such that computers were lined up in rows right next to each other along the walls, rather than being spread out. These girls regularly moved files back and forth from lab computers to group workstations via file sharing or floppy disks. Upon seeing how well this arrangement worked for those girls, coupled with the fact that most students had finished the research phase of their work, we opened up the lab for regular MicroWorlds use. Changes took place almost immediately. Rather than waiting to be told what to do by boys and whether or not they would be *allowed* to work in MicroWorlds for the day, many girls often grabbed their floppy disks and headed off to the lab with a long list of things they wanted to accomplish on their own.

Creating a new "space" on the physical plane of the design environment in which to do programming allowed individuals to work and help one another in the way they felt most comfortable. Most boys worked at their own individual stations, which were spread out across the classroom, and would call one another over for help with specific things. Many girls (and a few boys), on the other hand, preferred to work collaboratively and used the space in the adjacent computer lab so that they could talk and give programming/design advice by glancing over at one another's screens while they were all working together. This arrangement seemed to encourage those involved to stay on-task longer and develop innovative ideas so that they could be shared with the rest of the community. These findings are consistent with existing research that shows that motivation and achievement are higher among girls in peer groups with similar mindsets and academically oriented goals (Fredricks & Alfeld-Lo, 1997). As documented by students' log files, the amount of programming being done by girls went up after the changes in the "physical space" of the design environment took place. It should be noted that not *all* boys or *all* girls used the lab computers or workstations in gender-specific ways. The point is rather that the addition of another "space" in which to program allowed students of either gender to find a workplace that was compatible with their own preferences.

"Paying the Price"

While in the previous sections we reported on the positive impact of creating spaces that allowed girls to work more productively, here we identify an issue that raised some concern. There is evidence that support structures implemented within the science design project facilitated girls' transformation from low- to high-status activities; however, we see a potential for girls to pay a price in their struggle for greater computer access. These results were based on case-study data from seven students (three girls and four boys) who participated in the science design project twice over a two-year period. In the first year, these students worked on their projects independently. During the second year of the project, which provided the data for this study of gender differences in negotiating computer access, these students faced a new challenge of planning and managing a team project. Both prior to and at the conclusion of the second project, the students were asked in questionnaires and interviews to explain what is "planning" with respect to projects. Responses were classified in one of two categories: (1) top-down beliefs and strategies suited to well-defined problems (examples include doing things ahead of time, such as setting goals, deciding what to do, and deciding an order for doing things); and (2) bottom-up beliefs and strategies that lend themselves to ill-defined design problems (examples include doing things in a more iterative manner, such as brainstorming different ideas for what the artifact should be, reviewing and/or changing one's plans in response to new information, and recognizing the need to get more information about a topic while working on a project). Responses from three of the four boys demonstrated that while they had not abandoned beliefs about the usefulness of top-down strategies, their planning repertoire included an increased percentage of bottom-up strategies at the end of the science design project. This was not the case for the girls, who at the end of the project had not expanded their planning repertoire to include more bottom-up strategies. While the girls' focus on conflict resolution led to increased status and computer access, it appears that boys benefited from greater initial computer access and from their focus on project work rather than on solving collaborative problems; they developed a more flexible view than the girls of what it takes to plan and manage a project.

Discussion

In our analysis of results, we paid close attention to the various factors that helped girls change their status. In the following discussion we want to address several key issues in designing and implementing computer-based learning environments, consideration of which can help support girls and boys equally in their learning endeavors.

Timing of Interventions

One issue that needs to be addressed concerns the place and timing of interventions. Previous intervention models, such as science and technology after-school programs and summer camps, try to reach out to female student populations in high schools and colleges. These are important programs, but we hold that the timing of such interventions is too late, considering that girls form many beliefs about themselves and subject domains during the elementary school years. For that reason we propose to situate interventions much earlier in development, thus providing younger girls with opportunities to interact with advanced technologies and science in substantial ways.

Girls as Software Producers

A related issue is the emphasis we place on children as producers, rather than strictly consumers, of computer software (Kafai, 1995). Our findings suggest that while the software industry currently strives to create products for girls as software consumers, the idea of girls as software designers may be still hard to swallow for 10–12 year olds. In the analysis of factors predicting access to the full practice of software design at T1, we found that gender was the only significant predictor. This finding is of particular interest because past research on participation patterns in groups engaged with more traditional school tasks has concluded that while gender is often one important factor in collaborative interactions, academic skills, popularity, and ethnicity usually also play strong roles in affecting interaction and access (see review by Cohen, 1994). We found that in the activity of collaborative software design, however, gender was the most salient characteristic. These results are somewhat disturbing. They suggest that even at a young age, children's actions with respect to classroom technology are very gender biased—another argument for the early positioning of interventions mentioned above. The change in access most girls experienced, however, shows that these behavior patterns are not immutable in a supportive environment.

Final Thoughts: New Era, New Questions

Education is currently in the throes of a trend in project-based learning (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991) for computer use to be integrated into long-term, multifaceted projects such as the one documented here. Computers no longer reside solely in a distant laboratory, with few if any ties to other classroom activities (Kafai, 1995). These new developments have staggering implications for the way we think about gender and computer use. If girls have little access to computer resources in these integrated classroom settings, they not only miss out on the opportunity to develop technological literacy, but they also risk missing out on learning other subject matters being mediated by computer use as well.

Even when it appears that girls are spending an equal amount time in front of the computer, advocates of gender equity still should not be entirely at ease. In our project, which was supposed to provide students with creative and innovative opportunities, girls' initial computer work consisted mostly of word processing and consumer-based use of software encyclopedias. These results are cause for concern. We are reaching a point in gender and technology research where the issue may no longer be about if girls are using the computer but rather *how* are they using it. Results from our study confirm this, in that there was an initial division of labor where boys dominated all of the available "cutting-edge" technology, such as the Internet and the programming software. Through creating new spaces in the environment to address girls' needs, we found ways to alleviate this situation and provide opportunities for girls to gain access. We would also argue that such measures are not only helpful but necessary to ensure the continuation of progress toward gender equity in technology environments.

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