Give Girls Some Space: Considering Gender in Collaborative Software Programming 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, our approach was different. The current study examines a three-month software design activity in which mixed teams of girls and boys [10-12 year olds] designed and implemented multimedia astronomy resources for younger students. In this context we assessed how students' levels of access to technology were impacted by gender differences at the project outset, and how these participation patterns changed throughout the project duration. We found that the documented positive change in girls' access was impacted by the configuration of social, physical, and cognitive "spaces" in the project environment. We discuss the implications of these results in regard to issues surrounding the development and maintenance of gender equity in computer use and further research.

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 have 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, et. al. 1994]. While each of these variables alone or in combination have an impact on situating girls' interactions with computers, we examined more closely girls' access to computer resources in classroom activities and collaborative groups. 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 expertise in a variety of mixed-gender settings.

Toward that end, we investigated students' activities and collaborations during a three-month long 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, 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 which 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 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 tend to dominate computer space [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 used more 'non-contact' methods such as verbal requests [Inkpen, Booth, & Klawe 1991]. Boys also are more likely to initiate and maintain control of school computers during non-classroom hours such as lunch time and before or after school [Canada & Brusca 1991].

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 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]. 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 acheivement is not affected by these differences in interaction, girls' self-esteem and interest in the subjects in question may suffer [Wilkinson, Lindow & Chaing 1985].

It appears that bringing together collaborative work situations with computer use amplifies some of the gender issues found in either situation alone. In attempting to ensure that girls will have the 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.

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 WWW.

Heterogeneous groups of 3 to 4 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. 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 3-4 hours per week on the project for a period of 3 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.

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. 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. Activities were classified into the scheme in Table 1 via the first author's observations of student arguments over "who would get to do __ today" and conversations with students about the desirability of certain activies.

Table 1. Activity Status Classification & Coding Scheme

High Status Activities	Medium Status Activities	Low Status Activities
Microworlds programming	Grolier's Multimedia Encyclopedia	Book Corner research
Internet research	Asimov CD ROMs	Drawing screens on paper
Leading software demo	Word processing	Team progress reports
Helping others program	Watching someone program	Doing nothing

For data analysis, students received status codes based on whether or not they typically engaged in high, medium, or low status activities. Fieldnotes and videotapes taken during two time periods were coded. The first time point [T1] was after the first 3 weeks of the project, and second time point [T2] was approximately two weeks before the end of the project. On each day during the two selected time periods, students' activities were catologued and coded according to Table 1. For each instance a particular student was present in a set of fieldnotes or tape on a given day, he or she received a 3 for engaging in one of the high status activities in Table 1, a 2 for medium status, and a 1 for low status. Sets of notes and videotapes were then aggregated, and students received a single status score for the aforementioned two time segments. We then conducted multiple regression analyses to determine what factors predicted status at T1, predictive factors at T2, and change in status levels over time.

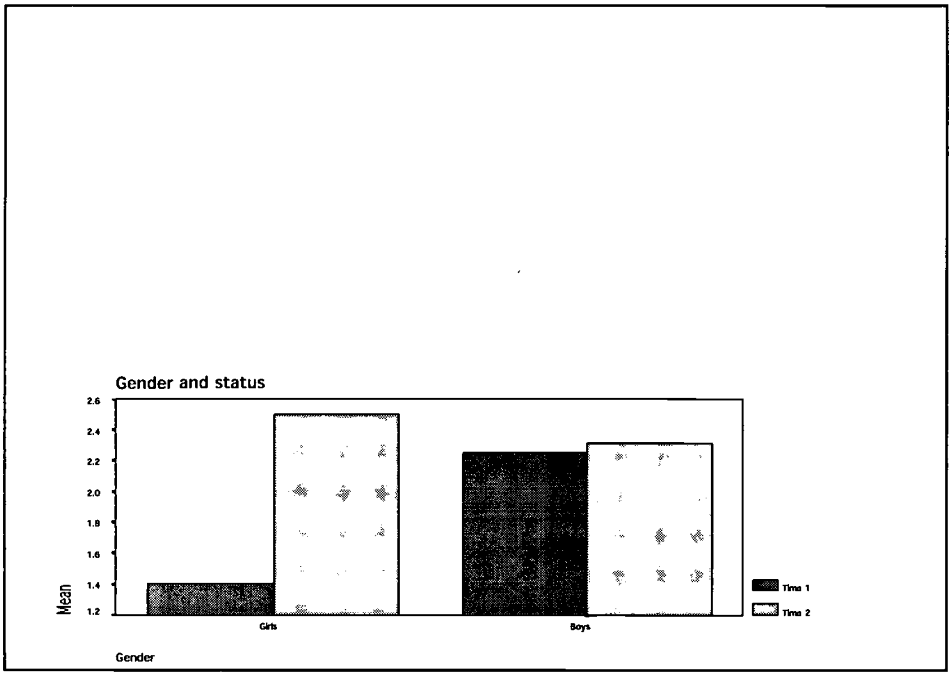
Results

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. Gender was the only significant factor [$p < .001$]. Statistical results confirmed what we had observed during student work time: a significant number of girls were engaged in low status activities which 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 time 2 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 of remaining low status throughout the duration of group projects.

Figure 1. Changes in Status Over Time for Each Gender



Give Girls Some Space

So how did these status changes for girls take place? 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 which 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

Early in the design project, the task of organizing and reporting on groups' 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 which 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 which 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 less 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

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 [Canada & Brusca 1991]. In our design project the group stations were spread throughout the classroom, making it difficult for students in different teams to communicate with one another without leaving their seats. 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. Thus the arrangement of physical space in the classroom seemed to be holding girls back--until they changed it.

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. Girls began moving 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, instead 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, worked collaboratively and used the space in the adjacent computer lab, so 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 they could be shared with the rest of the community. Thus the addition of another "space" in which to program allowed students of either gender to find a workplace which was compatible with their own preferences.

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. Furthermore, we find it important that girls are not only introduced to technology as consumers; hence our focus on students as *producers* of software artifacts such as multimedia resources or software games [Kafai 1995].

New Era, New Questions

Education is currently in the throes of a trend in project-based learning [Blumenfeld, et. al. 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 male domination of technology and provide opportunities for girls to gain access. We would also argue that such measures are not only helpful but necessary to continue to address issues of gender equity in technology environments.

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