Girls (and Boys) and Technology (and Toys)

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In this inquiry, I have examined how 11- to 14-year-old students used technology to design and produce toys. While most students created toys by hand, I explored the range of computer use, and male and female students' views of this integrated unit. In addressing three specific research questions, I found that a project-based unit allowed students to use technology in meaningful ways, that the wide variety of computer use disrupted typical gender-technology patterns, and that computer use allowed some shifts in traditional gender-technology relations.

L'étude porte sur les diverses utilisations de l'ordinateur et sur la manière dont les garçons et les filles de 11 à 14 ans perçoivent l'unité intégrée qu'est un jouet conçu par ordinateur. Les résultats suggèrent qu'une unité axée sur un projet permet aux élèves de se servir de la technologie de manière intéressante, que la variété des utilisations de l'ordinateur modifie profondément les modèles typiques quant à la technologie et aux différences entre les sexes et que l'utilisation de l'ordinateur permet certains changements dans les rapports traditionnels entre la technologie et les sexes.

This was the best unit we did all year. I loved it when the little kids came to the Toy Fair and played with my puzzle. I couldn't believe how much they liked it. (12-year-old female student)

Girls and women are typically excluded from the images of the computer culture and glamourized in the video and entertainment industry (Knupfer, 1997; Turkle, 1984). These problematic images are compounded by the biases evident in children's games, classroom practices, and educational design that tend to favour boys (Klawe, Inkpen, Phillips, Upitis, & Rubin, 2002). Boys are more likely to make use of computers at home, and both boys and girls identify their fathers as the computer users in their families even when both the mother and father use computers at home (Margolis, Fisher, & Miller, 2000). Also, girls who become interested in computers are often ostracized by their female peers, as well as by boys, who are often unwilling to grant girls the coveted "hacker" status (Upitis, 1998). Boys are more avid players of video and computer games, which are a gateway into computing

(Provenzo, 1991; Turkle, 1995). Through games, boys learn to experiment and to take risks, and to develop complex strategies for sharing information with one another to “beat the game” (Koch & Upitis, 1996). These forms of learning transfer quite readily to the educational computing environment.

Some might argue that if it is not part of girls’ culture to use computer and video technology — either in terms of entertainment or educational technology — then perhaps it is misguided to design programs and strategies to engage girls to use such technology. However, a convincing counter-argument to this view is that provisions need to be made to account for the inequities that exist in many classrooms based on the use or non-use of technology. Teachers able to link computer use with girls’ interests are more likely to create the conditions needed for girls to thrive in a computer-rich environment (Klawe, Upitis, Inkpen, & Koch, 1997). Our research team explored such a link, where technology of various types was joined with students’ inherent and complex interest in toys.

TOYS AND TECHNOLOGY IN THE CLASSROOM

Over the past several decades many attempts to bring children’s love of toys and games into the classroom have been coupled with computer technology. Notable early work in the area of toys and technology included LEGO/Logo, where structures are created with LEGO building materials and interfaced with the Logo programming language (Papert, 1980) and specialized LEGO pieces including motors, lights, and sensors. Researchers (Hall & Hooper, 1993) have identified classroom features conducive to learning with LEGO/Logo, including the importance of involving parents and others when students undertake projects.

Others (Ching, Marshall, & Kafai, 1998; Cutler-Landsman, 1993) have paid attention to the role of Logo and gender. Hutchinson and Whalen (1995) found that working with LEGO/Logo helped girls in grades 3 through 8 to solve some challenging math and science problems, and to develop greater confidence in their problem-solving abilities. By designing and creating such items as washing machines and an elf cookie factory, girls pursued their ideas with the guidance of teachers and input from community members. Further, they learned that math and science problems were embedded in what might be stereotypically thought of as female pursuits.

GENDER ROLES AND IDENTIFICATION AND TOYS

Girls and boys begin to develop stereotypic knowledge about "girl toys" and "boy toys" in preschool years (Martin, Eisenbud, & Rose, 1995), and have firmly established views on toys and gender by seven years of age (Perry & Sung, 1993). This gender identification for toys persists throughout adolescence (McDonnell, 1994), and expands to related issues, notably technology and more generalized gender roles (Henshaw, Kelly, & Gratton, 1992; McDonnell, 1994). In their study with children from 4 to 10 years of age, Martin, Wood, and Little (1990) found that as children became older they made more rigid gender judgments in terms of behaviours, occupations, traits, and physical appearance. Further, the research of Francis (1997, 1998a, 1998b) with 145 children aged 7 through 11 revealed that children construct gender in opposition to one another, and that most children in this age group select gender-traditional occupations, as evidenced by role playing (Francis, 1998b).

What do such gender identities typically entail? From preschool through to early adolescence, girls tend to focus on the development of relationships, while boys often focus on objects (Inkpen, et al., 1994; McDonnell, 1994). Researchers have observed these differences in play, in social interaction, in children's self-descriptions, in adults' descriptions of children, and in children's written narratives (McDonnell, 1994; Nicolopoulou, Scales, & Weintraub, 1994). Researchers have claimed that experimentation with gender-specific boundaries is a natural and necessary stage of growth and development (Francis, 1998a; McDonnell, 1994; Thorne, 1993). Given these observations, the curriculum should allow males and females to express elements of their own gendered cultures, and also to experiment with non-traditional gender relations and expressions.

GENDER ROLES AND COMPUTERS

Mullen (1994) found that one way to engage girls more fully with technology was to provide entry points for girls and boys to shift traditional roles. Mullen suggested that such themes as women in history, men taking non-traditional roles, and the portrayal of boys in nurturing roles be regularly introduced in the classroom. However, this kind of exposure alone is not enough to help boys and girls think differently. More explicit changes, both in classroom structures and in the technology itself, are necessary (Caleb, 2000; Fiore, 1999; Flowers, 1998; Klawe et al., 2002; Wood, 2000). At least five such approaches have been identified in recent years.

First, researchers (Caleb, 2000; Fiore, 1999) have stressed the importance of creating an environment that provides opportunities for girls to use technology in any number of forms, including both familiar and unfamiliar materials and tools. They suggest that the range of materials is more important for girls than for boys (Caleb, 2000; Klawe, et al., 2002). Second, Wood (2000) has demonstrated the value of creating learning environments with "real-world" problems and a "sense of purpose" (p. 31), including such project-based learning as the design of toys and curriculum units for younger children. When such tasks are part of the learning environment, girls are more likely to become interested in technology and to shift to a higher-level status in the classroom in terms of their access to programming (Ching, et al., 1998). Third, several researchers (Ching, et al, 1998; Klawe et al., 2002; Koch & Upitis, 1996; Wood, 2000) have argued that, to shift girls' attitudes towards technology and success in using technology and, ultimately, success in entering technology-related fields, it is important to create "girls-only" conditions so that female students can work with their female peers and with adult females as they explore new technologies. Fourth, both scholars and game creators have suggested the creation of particular software to entice girls to become both interested in the content embedded in the software (Klawe, et al., 2002) and in the technology itself (Fiore, 1999). Finally, challenges to traditional gender-technology relations are critical. These challenges can be effected through role models in the school; guidance counselling; modification of facilities to make them more attractive to females; and summer, mentoring, and same-sex programs (Flowers, 1998).

PROJECT-BASED LEARNING AND SOCIAL INTERACTION

As early as the turn of the 20th century, educators recognized the value of project-based, purposeful classroom activity involving a large degree of social interaction and a natural integration of subject areas (Dewey, 1902, 1938; Kilpatrick, 1918). The importance of social interaction in cognitive development has also been acknowledged throughout this century (Cole & Scribner, 1974; Vygotsky, 1978) because students construct knowledge through their interactions with peers, ideas, problems, teachers, and materials (Papert, 1993). Ross (1993) has identified that using a constructivist approach in mathematics, science, and technology is particularly important for girls. Some of the other features of project-based learning such as planning and design, record keeping, interdisciplinary or integrated studies, teacher guidance, and self-assessment also contributed to meaningful learning (Welch, 1999; Wolk, 1994).

The use of computers as tools in the context of project-based learning has been heralded for three decades (cf. Papert & Solomon, 1971). Further, scholars (Kinnaman, 1994; Lebow & Wager, 1994; Turkle, 1984; Whitehead, 1993) have demonstrated that teacher support and knowledge is necessary to create exciting and inclusive classroom environments where computers are integrated in an authentic fashion. The notion that the most well-conceived, project-based units incorporating technology will fail to realize their potential without appropriate guidance and intervention on the part of the teacher is echoed by DeJean, Upitis, Koch, and Young (1999), who concluded that students required instruction from a teacher to make the mathematics embedded in a computer game more salient.

In summary, project-based learning involving technology and toys is likely to give rise to important learning for students when it (a) allows for non-traditional and traditionally gendered preferences to be expressed and to shift, (b) involves learning through social interaction with classroom members and others, and (c) is guided by a teacher knowledgeable in the use of computer technology.

RESEARCH FOCUS AND QUESTIONS

In this research, I explored student responses to a project-based unit of study called *Toys! Toys! Toys!*, developed by the students' grade 7/8 teacher. Based on the literature, I developed three major questions to guide the research:

- Did the unit allow students to use both computer and other forms of technology in a variety of ways that were meaningful and productive?
- Did the unit allow for traditionally gendered (constant) and non-traditional preferences to be expressed?
- Did the unit allow for shifts in traditional gender-technology relations, allowing girls to become more fully connected with the promise of technology?

CONTEXT

Classroom Setting

The class involved in the research, located in a mid-sized Ontario city, was one of four involved in the Electronic Games for Education in Mathematics and Science (E-GEMS) group during the 1994/95 school year.

The other three schools in which research studies took place during the same period were located in Vancouver, British Columbia (Klawe & Phillips, 1995).

All 29 students (12 females and 17 males) in a combined grades 7 and 8 classroom participated in the unit of study and in the research. Most were Caucasian and from lower middle-class, two-parent homes. They were 11 through 14 years of age. Their mid-career female teacher was well-versed in computer technology, and comfortable with a wide range of subjects, particularly mathematics and the arts. She was well respected by the students, parents, and colleagues.

Four Macintosh LC III computers with CD-ROM drives and two printers were available in the classroom. The students used word processing and paint programs and HyperCard extensively during the toys unit. In the 1994/95 year, much of the teaching and learning revolved around units of study incorporating a number of curriculum areas, and included such topics as advertising, poetry, heroes, illusions, and the toys unit described in the present paper.

The regular presence of four female researchers/research assistants as participant-observers in the classroom led to the cultivation of a closely negotiated relationship with the classroom teacher. There were in-class and after-school meetings with the teacher to determine how best to integrate the computers into the existing program, while, at the same time, stretching the boundaries of the curriculum through the introduction of the technology.

The Unit of Study

The teacher outlined the expectations for the unit through a one-page description of the outcomes that would result from students' explorations. She expected them to design and construct a toy, using a wide variety of materials and human resources. They also had to produce a number of additional products: design plans, logos, advertisements, and business cards. At least two of these products had to be developed with a computer. The other computer requirement, which was fulfilled in the computer lab in the school, involved learning to use a spreadsheet to create a fictitious toy order within a specified budget.

During the five-week unit, students worked individually or in small groups. At times, full-class discussions took place. The students, through a process of brainstorming, discussion, and negotiation, agreed on a set of criteria for a good toy, including such factors as safety for young children and durability of materials. Small groups sprung up spontaneously when students were working on a similar problem or using common tools. Students did some of the work individually, both in the classroom and at home, especially designing advertising slogans and materials, and writing their daily work journals. The teacher monitored progress through students' daily journals and through regular individual and small-group discussions. The unit culminated in a Toy Fair, where students displayed, demonstrated, and described their toys to other members of the school and the neighbourhood community.

METHOD

The researchers observed, solicited, and documented students' behaviours and reported thoughts during the five-week period that the unit took place, using extensive field notes, informal interviews, analysis of artifacts, and participation in class discussions and the Toy Fair (Patton, 1990).

Four students (pseudonyms are used) were purposefully selected (Patton, 1990) to represent the full range of technology use. Desiree and Matt designed games for the computer, and shifted in their thinking to some extent. Jane used the computer only as required in the project expectations, displayed no change in perspective, and had been identified, both in this context and in other classroom situations, as one of the students who did not find computer technology appealing (Upitis, 1998). Derek used the computer extensively for advertising, but chose to create his toy using woodworking tools.

ANALYSIS

I compiled a profile for each of the four students described above. For each profile, I identified the range and type of technology used; classified the types of toys created — traditional, non-traditional, and gender-neutral preferences; then identified the remaining themes in terms of learning through social interaction, identification with gender roles or preferences, and shifting gender roles or preferences. Once I completed the analysis and generated the four composite profiles, three research assistants (who had been involved in data collection) and the classroom teacher read through the descriptions. They offered a few small additions to the descriptions of Desiree and Matt, but did not disagree with any aspects of the four profiles. I also analyzed the artifacts of the other students in the class, and all the students were interviewed at the Toy Fair. From these artifacts, interviews, and general observations of the unit in progress, I created a composite portrait of the entire class.

FINDINGS: THE WHOLE CLASS

Toys and games appealed to all students in the classroom. Because the unit was designed so that the toys could be created for peers or for younger children (an important feature identified by Ching et al., 1998), some students made toys they thought would appeal to younger siblings or to younger students in the school while others designed games for themselves and their peers (e.g., one person made a chess game). Many of the girls made stuffed animals and many of the boys constructed their toys from wood, demonstrating traditional (constant) gender choices. Others made toys that crossed traditional gender boundaries — one boy constructed a wooden dollhouse. This unit made it possible for boys and girls to work according to their traditional or non-traditional preferences, and for the artifacts created in the context of those preferences to be valued. Girls were able to legitimately focus their energy on characters and relationships, which has been demonstrated to be important to engage girls in problem-solving and technology (Klawe et al., 2002; Wood, 2000).

Most students created something with their hands. There was a decided sense of pride for the students at the Toy Fair. For more than half the class, the unit lived on long after the Toy Fair was over. Some gave their toys to younger siblings and observed with pleasure their siblings playing with their creations; some displayed their toys in their own rooms or played with the toys themselves; and others (especially the creators of computer games) left their creations in the classroom and enjoyed continued interactions. These kinds of behaviours clearly indicate that the unit had the "sense of purpose" that Wood (2000, p. 31) identified as a feature of curriculum important to engaging girls, and that may account, in part, for what Ching et al. (1998) refer to as the higher-status achieved by one of the students described below (Desiree).

Students were encouraged to tap into a number of community resources as they developed their toys, and the Toy Fair involved the entire school community, parents, and the general public. Three reporters from different local newspapers came to take photographs and write stories. For some students, this community interaction made the project "real"—something outside the limited realm of the classroom (Upitis, Phillips, & Higginson, 1997).

FINDINGS: FOUR PROFILES

Desiree: "The Titanic*"*

Desiree took learning and schooling seriously. An avid reader, she liked to write poetry in her spare time. Desiree chose to create a computer game for the toy project. She learned to use HyperCard with the help of her peers and by using manuals; there was no classroom instruction on the use of HyperCard. Most of her efforts were spent on the game itself — partly because it was time-consuming to learn HyperCard, then design and debug the game, and partly because she was more interested in producing a good game than in spending time on what she viewed as peripheral activities, like creating business cards or posters.

When asked to describe her game, the *Titanic*, Desiree replied, "It's a choose your own adventure game, where you're trying to relive being on the *Titanic*. There are many paths through the game. I didn't count them. Some of them crossed each other, too."

Desiree had read a number of accounts of the sinking of the *Titanic*, and from these accounts compiled details about life aboard the Titanic before disaster struck. She also knew that a few people survived the disaster, so the game player who made the right choices would survive as well. At each new screen, she asked the player to make a choice: for example, at one point the player was asked to choose between dining in the main dining room or staying in his or her own room because of seasickness. The next screen would be contingent on the choice made on the previous screen, and the right combinations of choices would result in surviving the disaster and winning the game.

The *Titanic* was an unusual game because it was entirely text-based. Desiree explained that she chose not to use graphics because she wanted players to concentrate on the story: "I tried to put in enough detail so you could make up your own pictures, in your mind." She conceded that she had planned to use minimal graphics — "little pictures on the bottom that would move when you clicked on a word" — but was unable to get the help she needed to create such graphics.

Although Desiree noted that "Scott got me started and showed me how to make fields for writing and how to link cards," she was often observed working alone on her game. She used an old Macintosh Plus computer tucked away in a corner of the classroom. The four other computers, networked in a cluster, were in the centre of much activity, talk, and laughter. Anticipating that she needed more time on the computer than her peers, Desiree picked the old computer because it was not as popular as the other computers. The computer "kept on breaking down and I had to keep rebooting it," but Desiree was glad to use this less powerful computer so she could work long stretches without interruption.

Desiree was justifiably proud of her end result: "Using the computer makes me feel professional. Everyone walks by you and says 'Wow! You must really know computers.'" She enjoyed showing her game during the Toy Fair, despite finding a bug "right when people came in." She spent little time on the advertising aspect of the unit and she quickly created by hand almost all her business cards and other paraphernalia, such as a doorknob hanger and buttons. The heart of the unit for Desiree was in making the game.

Derek: "The Dino-Bank"

Derek, a reflective and industrious student, created the Dino-Bank, a dinosaur with a slit in its back for saving coins. He said he wanted to create a "fun way for little kids to save money," and that by making the belly of the dinosaur clear, "kids could see how much money they were saving." Derek painted it purple, with large yellow polka dots all over the body and neck, and engaging facial features — the Dino-Bank looked as if it were smiling and winking. All Derek's advertising materials were also yellow and purple, with the exception of the interactive advertisement he created using HyperCard.

The Dino-Bank posed many design and construction challenges for Derek. When asked what tools and materials he used to construct his toy, he readily recited a list of some length, including "a scroll saw, a router, screwdrivers, computers, scissors, pencil and grid paper, wood, Lex-an, paint, screw, beady eyes, and glue." Derek described Lex-an as "unbreakable plexi-glass," something he had learned from his father who "works in a glass company and knows about this kind of stuff." The Lex-an was needed because Derek tenaciously maintained that "kids would like it more if they could see inside."

With the support of his classroom teacher, Derek interacted with people outside the immediate classroom community to make his Dino-Bank. A teacher from the local high school helped him "router out the middle strip," a groove where the Lex-an could rest in the purple and yellow wood frame. Derek used a wide variety of resources to create the toy he had envisaged while retaining a sense of ownership of the toy; while others had helped, "it was really my idea and my toy."

Derek spent almost as much time working on the advertising of his toy as he did on the design and manufacturing aspects. He created a calendar, doorknob hangers, bookmarks, business cards, a computer-generated pie graph indicating projected sales, buttons, a Dino-Pencil, posters, and an interactive computer advertisement. He chose to create the computer advertisement since he "figured if it was on a computer and people could click on it, it would be more effective." Derek created the advertisement over many short sessions. He seemed undisturbed by the lack of availability of large blocks of time for computer use and the resultant break in continuity. As he put it, "I worked on it in bits and pieces . . . until it was done."

Derek found the journal-keeping tedious, describing the journals as "kind of boring." Although he recognized that his teacher had designed the journals and production records to keep the toy production on track, he stated, "I didn't need to do the journals to keep planning and going and on track."

Showing the Dino-Bank to friends, young children, parents, and members of the community during the Toy Fair was a highlight for Derek. Each time he described his toy to a new person, he was filled with enthusiasm.

Jane: "Cuddles"

Jane's energy was focused on friends — she was eager to move on to high school and explore all the complexities of the high-school social fabric. Jane completed school activities and projects with diligence but sometimes with little enthusiasm.

Jane was not enthusiastic about her toy — a stuffed animal called Cuddles. During our final interview, Jane indicated that her toy was still in her locker because she "hadn't bothered to take it home."

Jane spent relatively little time designing her toy: she drew a simple pattern for Cuddles and proceeded from there. In the end, she seemed to regret her lack of attentiveness at the design phase and commented that "one part of the head was longer than the other, and one of the arms was longer, and one leg was thicker." If she were to do the project again, she said she would "use a pattern from a book next time," rather than taking the extra time to design a pattern more to her liking.

Although Jane found the hand sewing difficult, stating that "it was hard to sew, I kept poking my finger," she nevertheless persisted until Cuddles was completed.

Jane used the computer only when required. She did almost all her advertising by hand, including drawings on her display board, a Cuddles lunch bag, a doorknob hanger, and a graph indicating projected sales as compared to other stuffed animals. She created only two items on the computer, a business card and a flyer. Her father helped her with the design of these items. Jane also submitted her computer-printed journal entries, after transcribing her handwritten notes on her home computer. She found the journal aspect of the unit "not too bad" although she didn't feel it helped her "stay on track." When asked why she didn't simply submit the handwritten form of her journal entries, Jane indicated that she liked to hand in computer printouts rather than handwritten notes. Jane didn't mind using the computer when she thought she could do a better job with it; she "just [didn't] want to use the computer just because I have to." Jane did not lack computer skills; she based her decision to use or not use the computer on her interests and needs.

Matt: "Puzzle Castle"

Matt dedicated large chunks of time and attention to things that interested him; working on his computer game was just the sort of thing that captured his imagination.

Matt's game, Puzzle Castle, was a major undertaking. It was a complicated game, with graphics, constructed with HyperCard. He described spending "*hours* on the game. Every period at school, I would work on the game. And then I worked on the advertising at home." Matt constructed his graphics in black and white, realizing even simple drawings would be time-consuming, in addition to working out the design, puzzles, and riddles associated with the game. Matt enlisted the help of a classmate from time to time.

Matt described the game: "It's about a knight who has to save a princess. He has to solve problems to free the princess, basically. Math problems and riddles." Asked where he got the idea for the game, Matt told us, "I was thinking of non-violent games, because we're not allowed to have violence. So I thought maybe riddles. I was thinking about a robot that would have to save a city. But I kinda thought mine was a better idea."

Matt's game was not unlike many popular video and computer games where the player's mission is to save a damsel in distress. When we saw Matt's game at the Toy Fair, one of us asked Matt if it were possible for a woman to be the hero. Matt had "never thought of that," but eagerly responded with a suggestion: "At the start, I could ask, please enter your gender. They could have the same story and riddles, but wherever it said 'princess' it would say 'prince.'" When asked if he had ever seen a game like that, he replied that he hadn't. We then asked him to think about whether a game like his, with a gender option, would sell. He seemed to think it would, responding, "Yeah, unless it was a really boring game. It would probably sell better. If some people felt stereotyped about games, like heroes as men and distressed damsels and stuff, then more girls would buy it, maybe."

Matt didn't like two aspects of the unit, the scale drawings and the journals, stating that the scale drawings didn't make sense for his toy. He disliked the journals, because they "got on [his] nerves" and played no role in "keeping him on track."

Matt enjoyed displaying his game and spent much time on the advertising aspects of the project. He created flyers and a banner on the computer, and a poster by hand. It was "fun organizing the stuff for the Toy Fair. It makes you feel like a big business man!" Paradoxically, Matt didn't like the unit on advertising, calling it "one of the boring ones." For Matt, it seemed that embedding the advertising in a project of his own made the advertising aspect relevant.

DISCUSSION

The evidence indicates that this unit was successful in terms of engagement, technology use, and traditional and non-traditional gender-technology relations. Ample evidence suggests that the project-based nature of the unit — that is, the creation of original artifacts — and the wide variety of technology that was both possible and necessitated by the nature of the creative undertaking, contributed to the success of the unit. In addition, the involvement of peers, the teacher, and people outside the classroom was important. As a result of these conditions, most children were able to become engaged through the expression of traditional gender preferences (both in terms of toys and technology).

I now return to the specific research questions outlined earlier: Did the unit allow students to use technology in meaningful ways? It is apparent that the success of this unit was partly due to the large number of ways that students could use computers and other technology. Further, the technologies were often used in combination to create something original and unique. As Caleb (2000) has argued, it is the *possibility* of creating ample ways of solving problems with unfamiliar materials and tools that is most likely to lead to success in technology design for girls, and this was no doubt a contributing factor to the success of the unit for the girls — and boys — in the classroom. Students were required to use the computer only in non-central aspects of the unit but were able to use the computer extensively if they so chose; consequently, there was a wide range of computer use, as illustrated by the four profiles. Some students learned to use a new kind of program and built a game based on that newly acquired ability. Desiree learned to use a computer in ways that made her an expert, a role more typically associated with males. For other students, like Jane, the relative freedom in terms of computer use meant that she could complete the project without being forced to use a tool that she found neither appealing nor particularly useful. Others, like Derek, used the computer for more than the required tasks, but constructed a toy with other tools. The students used the computer in a number of ways— for designing and printing business cards, writing up marketing reports, creating interactive advertising for the toy fair, creating signs for the toy displays, and working on daily journals. These uses reflect the ranges of use commonly found in the classroom with this age group (Upitis, 1998).

Did the unit allow both traditionally gendered (constant) and non-traditional preferences to be expressed? The wide variety of computer use appeared to disrupt some of the typical gender-technology patterns identified in the literature review and, indeed, those identified at other times within the particular classroom under consideration. That is, while in other classroom activities girls were much more likely to use computers as tools (e.g., for report writing, Upitis, 1998), in the context of the toys unit, girls were equally likely as boys to use the computer for creating marketing reports. During the entire school year, this was the unit where the students' use of the computers was most fluid. Students used computers (at home and at school) when they chose to, and moved easily from using a computer tool to using a saw or a sewing machine.

Although girls and boys both used computers for the toys unit during free time and the allotted class periods, the girls were more likely to use the computer during free time when the teacher created a space for them, that is, when she explicitly made a computer available for a female student (Koch & Upitis, 1996). Hutchinson and Whalen (1995) reported a similar phenomenon; girls were more likely and more comfortable in using LEGO / Logo facilities in same-sex rather than mixed gender situations.

Similar to the findings reported by McDonnell (1994), the boys demonstrated a particular interest in the attributes and production of objects or artifacts, whereas the girls showed a greater interest in social interactions. The boys were also more inclined to draw upon past experiences in handling materials or technology to support their work during the toys unit (i.e., traditionally gendered preferences). The girls, in contrast, were more focused on the story lines that were woven around these objects of human creation (another form of traditionally gendered preference).

Did the unit allow for shifts in traditional gender-technology relations? Some shifts in relations were indeed observed. In a few cases, the more entrenched and problematic gender-technology relations, as outlined at the beginning of the paper, shifted. This was particularly apparent for Desiree, as noted previously; however, Desiree was the only girl who made such a large shift. Given the statements made in the research literature about the difficulty in shifting gender-technology relations, one might conclude that a shift, even in one student, is noteworthy in that this particular curriculum unit allowed for such a shift while previous teaching and curriculum units had not.

Other shifts were more subtle, amounting to what might be seen as a greater awareness of gender issues, without major shifts in self-perception or behaviour (such as Matt's thoughts, when prompted, about female stereotypes and players).

In summary, this type of project-based curriculum unit allowed students with a wide range of abilities and interests to be engaged and, in some cases, profoundly challenged by their curriculum. The potential of this type of widely appealing and purposeful project-based unit for shifting girls' views of themselves as users of computer technology is promising. If students are to become more fully engaged in the use of technology, then teachers would do well to create opportunities for traditional gender roles to be expressed and to change.

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REFERENCES

Caleb, L. (2000). Design technology: Learning how girls learn best. *Equity and Excellence in Education*, *33*(1), 22–25.

Ching, C., Marshall, S., & Kafai, Y. (1998). Give girls some space: Gender equity in collaborative technology activities. *Proceedings of the 19th National Educational Computing Conference, IR 018 902*, San Diego, CA.

Cole, M., & Scribner, S. (1974). *Culture and thought: A psychological introduction.* New York: John Wiley & Sons.

Cutler-Landsman, D. (1993). Bridging the gender gap with LEGO TC Logo. In D. Watt & M. Watt (Eds.), *New paradigms in classroom research on Logo learning* (pp. 91–99). Eugene, OR: International Society for Technology in Education.

DeJean, J., Upitis, R., Koch, C., & Young, J. (1999). The story of Phoenix Quest: How girls respond to a prototype language and mathematics computer game. *Gender and Education, 11*, 207–223.

Dewey, J. (1902). *The child and the curriculum.* Chicago: University of Chicago Press.

Dewey, J. (1938). *Experience and education.* New York: Collier.

Fiore, C. (1999). Awakening the tech bug in girls. *Learning and Leading with Technology*, *26*(5), 10–17.

Flowers, J. (1998). Improving female enrollment in Tech Ed. *The Technology Teacher*, *58*(2), 21–25.

Francis, B. (1997). Power plays: Children's constructions of gender, *Gender and Education*, *9*, 79–91.

Francis, B. (1998a). *Power plays: Primary school children's constructions of gender, power, and adult work.* Stoke on Trent, U.K.: Trentham Books, Ltd.

Francis, B. (1998b). Oppositional positions: Children's construction of gender in talk and role plays based on adult occupation. *Educational Research*, *40*, 31–43.

Hall, I., & Hooper, P. (1993). Creating a successful learning environment with second and third graders, their parents, and LEGO/Logo. In D. Watt & M. Watt (Eds.), *New paradigms in classroom research on Logo learning* (pp. 53–63). Eugene, OR: International Society for Technology in Education.

Henshaw, A., Kelly, J., & Gratton, C. (1992). Skipping's for girls: Children's preferences of gender roles and gender preferences. *Educational Research, 34*, 229–235.

Hutchinson, E., & Whalen, M. (1995). Mathematics and science: Female students and LEGO TC Logo. *Computing Teacher, 22*(4), 22–25.

Inkpen, K., Upitis, R. Klawe, M., Hsu, D., Leroux, S., Lawry, J., Anderson, A., Ndunda, M., Sedighian, K. (1994). We have never forgetful flowers in our garden: Girls' responses to electronic games. *Journal of Computers in Mathematics and Science Teaching, 13*, 383–403.

Kilpatrick, W.H. (1918). The project method. *Teachers College Record*, *19*, 319–335.

Kinnaman, D. (1994). The leadership role: Best of all . . . it isn't teacher-proof! *The practical application of technology in public schools: Professional issues in public education*. Hartford, CT: Connecticut Education Association.

Klawe, M., Inkpen, K., Phillips, E., Upitis, R., & Rubin, A. (2002). Phoenix Quest in the classroom. In N. Yelland & A. Rubin (Eds.), *Ghosts in the machine* (pp. 209–227). New York: Peter Lang.

Klawe, M., & Phillips, E. (1995, October). *A classroom study: Electronic games engage children as researchers*. Paper presented at the Computer Support for Collaborative Learning '95 (CSCL 95), Bloomington, Indiana.

Klawe, M., Upitis, R., Inkpen, K., & Koch, C. (1997). The story of Phoenix Quest: Developing an appealing mathematical computer game for girls (and boys). *Proceedings of the Grace Hopper Memorial Conference on Women and Computing*, San José, California.

Koch, C., & Upitis, R. (1996). Is equal computer time fair for girls? Potential Internet inequities. *Proceedings of the 6th annual International Conference of the Internet Society*, Montréal, Québec.

Knupfer, N. (1997). Out of the picture, out of the club: Technology, mass media, society, and gender. *Selected readings from the 1996 Annual Conference of the International Visual Literacy Association, IR 018 353,* Cheyenne, Wyoming.

Lebow, D., & Wager, W. (1994). Authentic activity as a model for appropriate learning activity: Implications for design of computer-based simulations. *Proceedings of Selected Research and Development Presentations at the 1994 National Convention of the Association on Educational Communications and Technology, Research and Theory Division, IR 016 784*, Florida.

Margolis, J., Fisher, A., & Miller, F. (2000). Caring about connections: Gender and computing. *IEEE Technology and Society Magazine*, *18*(4), 13–20.

Martin, C., Eisenbud, L., & Rose, H. (1995). Children's gender-based reasoning about toys. *Child Development*, *66*, 1453–1471.

Martin, C., Wood, C., & Little, J. (1990). The development of gender stereotype components. *Child Development*, *61*, 1891–1904.

McDonnell, K. (1994). *Kid culture: Children and adults and popular culture*. Toronto: Second Story Press.

Mullen, J. (1994). *Count me in: Gender equity in the primary classroom.* Toronto: Green Dragon Press.

Nicolopoulou, A., Scales, B., & Weintraub, J. (1994). Gender differences and symbolic imagination in the stories of four-year-olds. In A.H. Dyson & C. Genishi (Eds.), *The need for story: Cultural diversity in classroom and community* (pp. 102–123). Urbana, IL: National Council of Teachers of English.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York: Basic Books.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. New York: Basic Books.

Papert, S. & Solomon, C. (1971). *Twenty things to do with a computer*. Artificial Intelligence Memo. no. 248. Cambridge, MA: Massachusetts Institute of Technology.

Patton, M.Q. (1990). *Qualitative evaluation and research methods*. Newbury Park, CA: Sage.

Perry, L. & Sung, H-Y. (1993, June). *Developmental differences in young children's sex-typing: Automatic versus reflective processing*. Paper presented at the Biennial Meeting of the Society for Research in Child Development, New Orleans, LA.

Provenzo, E. (1991). *Video kids: Making sense of Nintendo.* Cambridge, MA: Harvard University Press.

Ross, C. (1993). *Girls as constructors in the early years: Promoting equal opportunities in maths, science, and technology.* Stoke-on-Trent, U.K.: Trentham.

Thorne, B. (1993). *Play: Girls and boys in school.* Piscataway, NJ: Rutgers University Press.

Turkle, S. (1984). *The second self: Computers and the human spirit.* New York: Schuster.

Turkle, S. (1995). *Life on the screen: Identity in the age of the Internet.* New York: Simon & Schuster.

Upitis, R. (1998). From hackers to luddites, game players to game creators: Profiles of adolescent students using technology in a classroom setting. *Journal of Curriculum Studies, 30*, 293–318.

Upitis, R., Phillips, E., & Higginson, W. (1997). *Creative mathematics: Exploring children's understanding*. London, U.K.: Routledge.

Vygotsky, L. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Welch, M. (1999). Analyzing the tacit strategies of novice designers. *Research in Science and Technological Education*, *17*(1), 19–34.

White, R. & Gunstone, R. (1992). *Probing understanding.* London, U.K.: The Falmer Press.

Whitehead, B. (1993). Classroom computers: A new approach. *Principal*, *73*(1), 34–36.

Wolk, S. (1994). Project-based learning: Pursuits with a purpose. *Educational Leadership*, *52*(3), 42–45.

Wood, J. (2000). The girls have it! *Instructor*, *109*(6), 31–35.

Young, J., & Upitis, R (1999). The microworld of Phoenix Quest: Social and cognitive considerations. *Education and Information Technologies, 4*(4), 1–18.

SOFTWARE

HyperCard. Apple Computer Inc., 1993.

LEGO/ Logo. LEGO Dacta, Markam, ON & LOGO Computer Systems Inc. Lachine, QC.