Children’s Views of Technology: The Role of Age, Gender, and School Setting

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Abstract:

This study discusses the influence of age, gender, and the school/community context on elementary-age children's thinking about computer technology. Acting as teacher-researchers 23 undergraduate elementary education majors in the Professional Development School program at the University of North Carolina at Greensboro asked selected children in their Kindergarten-Grade 5 classes to "draw a technologist" and interviewed them about their understanding of computer hardware and software and related gender issues. Qualitative analyses of the children's drawings and interviews indicated gender differences and developmental trends in children's thinking about technology. For example, younger children drew computers much larger than themselves and set the computers in home or school settings compared to older children who drew the computers in proportion to themselves and placed the computers in school or work-related settings. Also, while both boys and girls could name software with male characters only 6% could think of any software with female characters. Differences with respect to access to computers at home associated with socio-economic status in the two school settings did not materialize in this study. The value of engaging prospective teachers in inquiry, action-oriented research about children's thinking as a form of teacher development is also discussed.

Many variables affect children's experiences with and thinking about computer technology including input variables, process variables, and output variables (Janssen Reinen & Plomp, 1994; Sutton, 1991). For example, access to computers at home and school, and socialization factors, such as differential expectations for males and females, are input variables because they impact how boys and girls differentially experience computer technology. Process variables include equity issues at home or at schools where children often have unequal access to or experiences with computers depending on their gender, age, race, economic status, and the type of school they attend. Finally, children's attitudes about computers and skill with computer-based technology are important output variables to consider in understanding children's thinking about computer technology.

This paper describes a study that looked at several input and process variables with regard to elementary-age children's views of computer technology including the role of age, gender, socio-economic status (SES), and school/community context. This study was also designed to help prospective teachers learn how to inquire about some of these issues and to understand how children view technology and the role of the technologist in their schools. Our analyses of interviews with elementary-age children and of children's drawings of a technologist are reported in this paper. Implications for teacher education are also discussed and suggestions for further inquiry into children's thinking with regard to computer technology are presented.

Article:

REVIEW OF THE LITERATURE

GENDER ISSUES AND TECHNOLOGY EDUCATION

Studies about some of the output variables that influence children's view of computer technology, such as computer attitudes and computer use, show that boys have more access to computers at home and at school than girls do (Becker, 1983, 1986; Martinez & Mead, 1988; Sutton, 1991), display more positive attitudes toward computer technology (Becker & Sterling, 1987; Krendl, Broihier, & Fleetwood, 1989; Sutton, 1991), and show a higher level of interest in computers than girls do (Campbell & Fein, 1986; Krendl, at al., 1989; Martinez & Mead, 1988; Middleton, Littlefield, & Lehrer, 1992; Miura & Hess, 1983; Sutton, 1991). However, more recent studies indicate a trend toward equality in that gender differences in the use of and attitudes toward technology are not significant for Kindergarten (Bergin, Ford, & Hess, 1993) and elementary-age children (Lage, 1991; Martin, Heller, & Mahmoud, 1992; Martinez & Mead, 1988; Janssen, Reinen, & Plomp, 1994). Some studies even show that girls have more favorable attitudes toward computers than boys (Plamondon, 1994), at least for certain tasks. However, these findings change as children get older (Reece, 1986).

In looking for reasons why gender differences show up in some studies and not others, researchers have pointed to several possibilities: lack of female role models for girls in the media and in some schools (Campbell, 1984; Sanders & Stone, 1986), parental influence and gender expectations (Benyon, 1993; Campbell, 1984; Sutton, 1991), inequities in access to computers (King, 1987; Lockheed, 1985), the influence of computer software (McInerney & Park, 1986), and variability in classroom climate (Benyon, 1993). In fact, several studies place the onus of gender inequity with regard to computer technology squarely on the schools (Benyon, 1993; Campbell & Fein, 1986; McInerney & Park, 1986; Miura, 1986; Miura & Hess, 1983).

RACE AND CLASS ISSUES IN TECHNOLOGY EDUCATION

In addition to gender differences often favoring male competence with computers, early NAEP studies (National Association of Educational Progress at Educational Testing Service) conducted in the United States noted that race, ethnicity, and class were also factors related to computer access, experience, and competence (Martinez & Mead, 1988). Computer competence in these studies was associated with differential access to computers in the home and inequitable experiences with computers at school. Overall, children from families who owned computers, white males, and students from high SES metropolitan areas showed distinct advantages over minorities, females, and children from low SES areas with regard to computer access and competence (Martinez & Mead, 1988). However, as Martinez and Mead (1988) also pointed out, it is always important to understand that school instruction and access at home are as important and as variable within demographic subgroups as they are between them.

Sutton's (1991) extensive review of the research in the 1980's on equity issues that surround computer use emphasized gender, social class, ethnic, and racial factors as sources of inequities in computer use across the numerous studies she surveyed. Her analysis revealed that low SES and minority groups have less access to computer technology at home and school and that patterns of computer use in many schools perpetuate and even aggravate the inequities of race, class, and gender. Sutton suggests more research on the impact of computers on poor and minority children with a focus on between-school differences, which this study begins to address by comparing children's thinking about technology in two very different school-community contexts.

DEVELOPMENTAL ISSUES IN TECHNOLOGY EDUCATION

In her early work on how various groups of people relate to computer technology, Turkle (1984) described how young, American children consistently ascribe attributions of anthropomorphism to computers and how this kind of thinking develops with age. She found that as children develop over time they change their rationale for their thinking that the computer has human properties from physical to behavioral and finally to psychological explanations. Based on her interviews of 63 children who were naive about computers compared to 25 computer-experienced children, Turkle found that younger children below age 8 think that computers are probably not alive, basing their judgment on the computer's lack of traditional physical criteria, such as no movement, or no growth. However, even as children above age 8 grow to realize that the computer is definitely not alive, in the traditional sense that it does not move or grow or eat, they still believe that it has psychological properties that make it "sort of alive." Turkle's work is intriguing and helpful in understanding the drawings and the interview responses of the children in this study.

In summary, the work of many researchers (e.g., Bergin et al., 1993; Krendl, et al., 1989; Lage, 1991; Reece, 1986) tells us that while girls and boys may begin school with similar interests in and aptitudes for computers, this changes as they develop. As children move through the elementary grades and into middle and high school, girls tend to show less interest in computers than boys. Why and how this happens should be of concern to teachers and parents. With these factors in mind, this inquiry project was designed for preservice teachers serving as "teacher researchers" to gather children's drawings and collect interviews to learn more about what children think about computer technology and the role of the technologist.

USING CHILDREN'S ARTWORK

Children's drawings have been used as research tools in numerous studies for a variety of purposes and found to be a powerful means of assessing children's attitudes (Martin, Heller, & Mahmoud, 1992). There are advantages to asking young children to draw pictures over having them read and respond to a printed survey. For example, they may perceive a printed questionnaire as a test with right or wrong answers (Martin, et al., 1992), may not always read well, or interpret the questions asked in the manner intended. Several studies used children's artwork as a vehicle for understanding their thinking about the gender and role of mathematicians, scientists (Chambers, 1983), and toward computers (Martin, et al., 1992). Studies that ask children to "draw a scientist" or "draw a mathematician" consistently report that children of both sexes draw pictures of male mathematicians and male scientists. Dennis (1966) claims that children's drawings reflect group values more accurately than other kinds of data-gathering instruments and Lowenfeld and Brittain (1987) state that children's artwork represents their mental images and are the result of their thinking process. Hence, in addition to interviewing children, we also sought to collect and analyze their drawings of computer technologists.

BACKGROUND AND CONTEXT FOR THIS STUDY

PROFESSIONAL DEVELOPMENT SCHOOLS

Some Professional Development School (PDS) programs, such as the one at the University of North Carolina at Greensboro (UNCG), have activity-oriented, inquiry-based programs that engage prospective teachers in classroom action research and other reflective practices as part of their preparation to become elementary school teachers (Ammon & Levin, 1993; Fosnot, 1989; Zemelman, Daniels, & Hyde, 1993). For example, in our PDS program at UNCG teacher candidates conduct case studies of individual children, exchange reflective dialogue journals with peers and faculty, conduct peer observations, discuss and write dilemma-based cases, and develop teaching and technology portfolios over two years as part of their teacher preparation program. We believe that providing various inquiry experiences for prospective teachers helps them gain an understanding of how children think, which will make them better teachers. Toward this end, we ask our teacher candidates to serve as teacher-researchers and conduct group inquiry projects early on in their two-year program, prior to conducting their own case studies or action-research projects later in the program.

As a part of the group inquiry project described in this paper, 23 undergraduate teacher candidates at UNCG gathered the data for this study to learn how children think about computer technology and gender issues related to technology. Both of these topics were a focus of this PDS team during their second of four semesters in the PDS program. Serving as teacher-researchers, these prospective elementary grade teachers asked 65 children in Kindergarten-Grade 5 classes to "draw a technologist" and then interviewed the children about their understanding of computer hardware and software. The fact that these prospective teachers were doing 10-hour weekly internships in two different school contexts was intriguing to us. Given Sutton's (1991) call for more research on the impact of technology in different school settings, this study seemed promising.

Georgetown Elementary. Located in a large, recently consolidated school district, one of the sites for this study, Georgetown Elementary, is situated in a suburban, mainly white, middle to upper middle class, neighborhood. Georgetown has a student population of about 550 children and a 30:1 student to computer ratio. Georgetown students have access for about 30 minutes once a week to a small, 10-station Apple Macintosh computer lab located off the school media center. The classroom teacher or the teacher's assistant is responsible for planning and providing the activities in this lab setting. The school district provides an itinerant, district-level computer specialist who visits Georgetown once a week to do maintenance and to offer staff development for the teachers. However, his job is to work with teachers only, not with the children. Most classrooms at Georgetown also have one Apple IIe and software appropriate for each grade level, but very few have printers attached to the computers. Furthermore, visitors to the classrooms at Georgetown would see these computers idle during the majority of the day, often not even plugged in.

Jefferson Elementary. Jefferson is a magnet school for science and technology located in an urban, low income neighborhood in the same school district. Jefferson has about 350 children, is 95% African-American with about 85% percent of the children receiving free or reduced lunch. The student to computer ratio is 5:1 at Jefferson due to the fact that the school district has granted significant amounts of money to Jefferson to support its magnet status over the past several years. For example, Jefferson has two computer labs: one is a 25-station IBM lab dedicated to computer-managed instruction (CMI) using Josten's software, and the other is a 25-station Apple Macintosh lab used for a variety of other computer-learning and computer literacy activities. These two computer labs are staffed with full-time computer specialists, both women. Students at Jefferson visit the Josten's lab twice a week for about 30 minutes to work on mathematics or reading / language arts-related programs. As is typical of CMI, these programs are mainly drill and practice and are individually prescribed and paced. All students at Jefferson also visit the Macintosh lab once a week for instruction by the computer specialist appropriate to their grade level and curriculum. Most classrooms at Jefferson also have two or three computers: either Apple IIe, Apple GS, or Macintosh models. Most classrooms also have one printer and a variety of appropriate software. Additionally, Jefferson has a student-produced TV broadcast daily and teachers make regular use of educational television in the lower grades and periodic use of laser discs in the upper grades.

DESIGN OF THE INQUIRY PROJECT

RESEARCH QUESTIONS

The basic questions that guided this study were:

1. How do Kindergarten through Grade 5 children understand technology and the role of a technologist?

2. What role does gender play in children's thinking about computer technology?

3. How does SES and the availability of computer technology impact children's experience with and understanding of technology?

PROCEDURES

Each of the 23 teacher-researchers who participated in this project was asked to select at least three children, both boys and girls, from their respective internship classrooms in the two different school sites described above. First, all of the selected children were asked to draw a picture of a technologist. If any children did not understand these directions they were prompted to draw a picture of someone working with technology or using computers. Second, the children were interviewed individually by the teacher-researchers about their drawings and then with a set of questions designed to find out about children's thinking about the "gender" of computer hardware and software and about their access to computers at home and school. These interviews were to be conducted individually and to take place during the school day either in the classroom or the media center. The teacher-researchers either tape recorded the interviews for later transcription and analysis or took notes on the children's responses. The interview protocol included these questions, although additional prompts were also encouraged at the discretion of the teacher-researchers:

1. Does the computer have a name?

2. Is the computer a he or a she? How do you know?

3. Are the characters in your favorite software program boys or girls? How do you know?

4. Can you think of software that has boys in it? girls? What is/are the name(s) of this/these programs?

5. Do you have a computer at home? If yes, Who uses it the most? What do they use it for? Who bought it? Who buys the software?

The data analyzed for this study included interviews from 65 children, drawings from 46 children, individual written analyses from 23 teacher-researchers, and written reports from each grade-level group based on a joint analyses of their individual findings. Several drawings were "lost" following the grade-level group work, which accounts for the difference in the number of children's interviews and drawings available for re-analysis.

PROCEDURES FOR ANALYZING THE INTERVIEWS

The children's interviews were subjected to analysis in five stages: First, the teacher-researchers who collected the actual interviews analyzed how each child responded to their questions regarding the computer's gender, whether it was male or female, and whether it had a name or not, plus additional questions about the gender of characters in their favorite software programs. Second, they reported how many children had access to computers at home as well as at school, whether home computers were "real" computers rather than game machines, who bought the computers, used them, and provided the software for them. Third, the teacher-researchers merged these data with information they gained from talking with the children about their drawings and wrote a summary analysis. Fourth, the teacher-researchers met with others who collected data from children at the same grade level across both school sites to compare their findings. Each of these groups wrote a summary based on their composite analysis of the children's drawings and their interview data. Fifth, as leaders of this inquiry project, the authors completed another level of analysis based on our own study of the teacher-researchers' individual and composite reports, transcripts of the children's interviews when available, and of the children's drawings. We looked for themes and trends across all the pictures and interviews by age/grade level, gender, and school setting using the method of constant comparative analysis (Miles & Huberman, 1984).

PROCEDURES FOR ANALYZING THE "DRAW A TECHNOLOGIST" PICTURES

The children's pictures were sorted and examined by grade level, by gender, and by school. Their pictures were analyzed with the following features selected to capture and highlight developmental differences in children's drawing (Lowenfeld & Brittain, 1987): Affect, Setting, Task, Details, Exaggeration, and Relative Size. We were interested in determining children's attitudes about technology by analyzing the Affect on the faces of the people in the children's drawings, and we assumed that smiling faces indicated positive attitudes. The background or Setting of their pictures was of interest because we hoped to assess how students viewed the various uses of technology and where they envisioned computers: at home, in school, in the workplace, or elsewhere. Analyzing the Tasks children showed in their drawings was another way to determine how children viewed the uses of technology: for work, for fun or play, for school, or for other tasks. The Details in their drawings were also of interest in helping us determine children's views of technology. We were particularly interested in what details their pictures included: computers, peripherals, other technology, people, and backgrounds. We were interested in the extent to which these details would give us insight about their depth of understanding of computer technology and how developed their drawing capabilities were. Related to the details we also looked for any Exaggeration in the children's drawings and for the Relative Size of the people in relation to the size of the computers. Exaggerations and Relative Size are indicative of children's egocentrism, of how objects appear to them in their world, and of how symbols are "real" to them (Lowenfeld & Brittain, 1987).

RESULTS AND DISCUSSION

ANALYSIS OF CHILDREN'S DRAWINGS

Based on our analysis of 46 drawings of a "technologist" completed by 24 boys (12 at Jefferson and 12 at Georgetown) and 22 and girls (10 at Jefferson 12 at Georgetown), the most interesting differences were by age/grade level and by gender. Among the drawings collected, 12 were done by Kindergarten children, nine by Grade 1 children, six by Grade 2 children, three by Grade 3 children, four by Grade 4 children, and 12 by Grade 5 children. There were no discernible differences in the drawings between the two school sites, although we had expected that the access to and focus on technology at Jefferson would influence the children's drawings. We also expected that the presence of two female computer teachers at Jefferson would influence the gender of the technologists portrayed in the drawings, but this was not the case.

In general, boys drew pictures of boys (92%) and girls drew pictures of girls (85%) at all age/grade levels, although the teacher-researchers noted that it was much harder to distinguish the gender of the characters in the drawings made by the K-2 children. In fact, many had to ask the younger children to tell them the gender of the people in their drawings. However, by Grade 3 the details in the children's drawings made it very easy to distinguish male and female characters based on obvious features such as hair style and clothing.

In the pictures where gender was readily discernible, only two boys drew pictures of female technologists, and three girls drew pictures of male technologists. The two boys who drew female technologists were students at Jefferson, so perhaps they were influenced by the female computer teachers at that school, although 10 other boys at Jefferson did not draw female technologists in their pictures. The three girls were also students at Jefferson but the pictures they drew with males in them were pictures of their family members, like their fathers. Most of the children drew themselves in their pictures, especially the younger students. As they got older there were more pictures of other people as technologists, usually doing work with computers. These developmental differences were to be expected, but actually seeing these results made the concept of egocentrism very concrete for the teacher-researchers, rather than just a theoretical proposition.

Other developmental and gender differences in children's perceptions of technology and of the role of a technologist were evident in their drawings as we analyzed them for the six features described above.

Affect. With few exceptions, students in this study drew pictures of a technologist and other people using technology that conveyed positive affect. Only one Grade 5 student drew a computer user with a frown, while 86% of all the children drew smiling faces in their pictures. There were no differences in this aspect of children's drawings by age, sex, or school setting. Positive affect was nearly universal across their drawings, perhaps indicating the children's positive feelings about technology (Lowenfeld & Brittain, 1987).

Setting. Younger children in Kindergarten through Grade 2 most often set their drawings of a technologist either in a house or at school, while older children in Grades 3-5 most often set their pictures either at school or in work-related contexts. For example, two Grade 5 students drew their technologist in a bank, while one Grade 3 student drew a 911 operator working in front of a set of three computers, and another drew a test pilot using computers. This illustration also included a satellite dish wired to a computer. Only three of the 27 children in Kindergarten through Grade 2 (11%) drew their technologist in a work setting. The remainder of the primary-grade children's drawings were set at home, school, or outside in nature.

Details. All the children across the grade levels drew fairly detailed pictures of the computers, including keys on the keyboards, a mouse, and details on the computer screens indicating whether the computer was being used as a word processor, for game playing, for doing math, or the like. This level of detail surprised us but is indicative of how children pay attention to the details of their experiences. However, their drawings of people were not as detailed as those of the technology, and many children used stick figures to represent their technologist. Interestingly, this finding replicates findings reported in the Martin et al. (1992) study that Chinese and Soviet children's drawings of people are much more detailed than those of American children who typically draw stick figures.

Exaggerations. In some of the details were evident in some pictures, but the most consistent and interesting exaggerations related to difference in Relative Size. That is, younger students in Kindergarten through Grade 2 exaggerated the size of the computer compared to the people in their drawings, while the older children in Grades 3-5 drew the computer and people in their pictures in more realistic proportions. More specifically, younger children drew the computer and peripherals much larger than the people, while older children drew the computer in a size proportional with the people in their pictures. There was no difference in this finding by sex or between the two schools (see Figure 1 and 2).

According to the work of Lowenfeld and Brittain (1987) on the cognitive and developmental aspects of children's artwork, the size of objects usually indicates their value and disproportions are the result of children's intentions and/or experiences, although the experiences may not be conscious ones. That is, pictures that children draw are the result of their mental images and of their thinking process. In summary, children's art is an indication of the way they comprehend and interpret space and objects. Therefore, we interpret the exaggerated size differences in young children's drawings of computers to be indicative of their thinking about technology. Perhaps computers appear to them to be larger than life, or to be powerful objects, or as ones they have not yet mastered. Or, perhaps the younger children drew the people smaller than the computers because they see themselves as small in size and short in stature compared to the rest of their world. One of the teacher-researchers interpreted these differences in his analysis of the drawings:

The students who draw the user larger may sense self-empowerment, whereas the smaller users may feel overwhelmed by the computer. On the other hand, they may see the computer as a source of power.

Task. Another interesting developmental difference in the children's drawings is that the older students in Grades 3-5 drew pictures showing the computer as a tool for doing work, rather than as a game machine. As mentioned earlier, the older children also set their drawings in work settings rather than home settings. In fact, they often labeled their pictures indicating the career or job and the technologist's use of the computer, with word processing being the most prevalent use of the computer displayed in their pictures. We interpret this to mean that older children think about technology and computers more as a tool for doing work and less as a game machine than do the younger children in our study. Interestingly, there were no differences in task by gender, or by school.

Findings from our "draw a technologist" task are very similar to another study that asked children to "draw computer users" (Martin, et al., 1992). In that study, boys also tended to draw males and girls tended to draw females, although girls were twice as likely to draw a male in their picture as boys were to draw a female. Furthermore, nearly equal percentages of the American and Soviet children in their study drew computers in school environments. However, twice as many American children in their study drew computers in home settings. Twenty percent of the Soviet children drew computers in office or work settings while only 8.2% of American children set their drawings in offices. Unfortunately, all of the children in the Martin, et al., comparative study were at least eight years old and no mention was made of exaggerations or relative size. Therefore, we do not know if our developmental differences were replicated in the same way as these gender issues.

ANALYSIS OF CHILDREN'S INTERVIEWS

Overall, the teacher-researchers who participated in this study reported that the children they interviewed seemed to understand what a technologist was: someone who works on a computer or uses computers on their job. This was true of Kindergartners through Grade 5 children at both schools. The few exceptions were the Special Education students (ages 9-12 and identified as educable mentally retarded) and the Grade 2 children at Georgetown who were confused by the term "technologist" and had to have more information given to them. One of the teacher-researchers asked her Grade 2 children more about the gender of a technologist and received an interesting response:

I asked the children later if they thought that all technologists were men. They immediately said no. They think that a technologist can be either a man or a woman. Then I asked them if technologists are mostly men. They said they probably are. This shows me that the children are starting to think that men and women can all do the same job, but they also realize that men still hold most positions such as this one.

Computers at home. There were no significant differences between the two school sites with regard to how many have a computer at home. We expected the economic differences in the two school populations would show up in this question but there was as much within-school as between-school variation: about half of the children interviewed at both schools said they had a computer at home. Eighteen of the 35 boys (51.4%)

interviewed said they had a computer at home, although when asked if it was a "real" computer or a game machine like Sega or Nintendo, several children were uncertain. Eighteen of the 30 girls (60%) interviewed also said they had a computer at home and a few were also uncertain of the difference between a "real computer" and a game machine.

Along with no gender differences regarding access to computers at home, there were also no differences in responses by age/grade level, which surprised us. Based on the literature we had predicted that boys and older children would most likely have computers at home, but this was not the case in our sample. Perhaps the studies that show fewer differences in access, attitudes, and competence with computer technology between boys and girls in elementary grades are the relevant ones for prospective teachers to consider. However, as one of the teacher-researchers wrote in her report:

I found it interesting that all three students I interviewed have a "real" computer at home because I was 16 before I got a computer and because they are so expensive...

When asked who bought the home computer and who used it the most, girls across all grade levels indicated that either their father or their parents bought it and used it the most in their family. However, of the boys who responded that they had a computer at home, one-third said they used it the most and that their Dad bought it; although two said that their mothers buy programs for it as well. Once again, there were no differences between the two school sites.

Computer gender and name. Based on their responses to the question "Does the computer have a name?" most of the 35 boys interviewed across all grade levels elected not to name the computer but said it was a male. They offered few explanations about why it was a male except that the user was a male or that it sounded like a male. One boy said it was a male because "It plays boy games and has violence and boys like violence and girls don't." Most of the boys just called the computer by its brand name. Eleven of the 30 girls (37%) interviewed said the computer was a girl and gave reasons such as, "Computers are helpful and boys are not" or because it has a feminine voice. It was interesting to us that most of the ten girls (33.3%) who said the computer was a boy also based their reason on the way the computer sounds. Only two of the girls (6%) said the computer was not real and therefore could not be a boy or a girl, while three of the boys (9%) also said it was just a machine and not alive. There were no discernible age or school site differences in children's responses about the gender or name of the computer.

There was much less anthropomorphism in the children's comments about the computer than we expected based on the work of Sherry Turkle (1984) who interviewed children about computer technology. Furthermore, many of the teacher-researchers indicated that they felt the children had not thought about the question of the computer's gender before, making them suspicious about the reliability of the children's responses. In fact, only one 5th grade boy showed any emotional or personal attachment to the computer in saying that he could talk to it about things that interested him.

In Turkle's study, the percentages of children who use physical criteria to discuss the aliveness of traditional objects declined from 85% of those age 8 and under to 30% of those over age 8. The percentage of those using psychological criteria ("it thinks", "it remembers things") to discuss the aliveness of computers and computer games increased from 62% of those 8 and under to 78% of those over age 8. In our study, children's thinking followed this same pattern, which helped us understand why even Kindergarten children said the computer couldn't have a name because it wasn't alive and why the 5th grader mentioned above said he could talk to the computer about things that interested him.

Male and female characters in software. Most of the children interviewed could name some software, mainly games, that had male characters. Many children, especially the boys, could also name software that had both male and female characters, animals, or aliens as characters. Most children based their thinking about the gender of the characters by their clothing, whether or not they had long hair, or by the character's name. Thirty percent of the girls interviewed said boys were the main characters in most programs and only 6% said that girls were the main characters. This was also true of the boys interviewed: only 6% could name software with female characters. There was no difference by grade level or at the two school sites.

From this evidence the teacher-researchers suggested in their reports that while boys regularly perceive the presence of both genders or their own sex in computer programs, there are fewer female characters portrayed or highlighted in computer software. This perpetuates at least one of the reasons cited in the literature for girls losing interest in technology as they leave elementary school and move into junior and senior high school (Krendl, et al, 1989; Lage, 1991). For example, one of the teacher-researchers wrote:

I think that all of the children I interviewed think computer technology is more for males. They all had trouble thinking of software programs that just had girls in them, even though they could easily name ones with boys.... The software programs (they) mentioned seemed more geared toward a male audience...

LIMITATIONS OF THE INQUIRY PROJECT

Although the teacher candidates who conducted this inquiry project learned some important lessons about technology and children, their understandings are limited by the small number of children they interviewed and to the two schools and one school district they experienced. The questions they asked were also limited in scope. In future studies, it will be important to work with a larger sample and to expand the scope and the depth of the inquiry. Fortunately, these teacher-researchers pooled their data in grade-level groups, talked with others in order to compare their findings, and had the opportunity to study all of the children's drawings across the grade levels. Although this may have helped them to extrapolate beyond their own small data set, they would certainly benefit from conducting this inquiry project either with their entire class or with a much larger sample of children. In fact, one of the teacher-researchers put it this way:

This was a very interesting assignment. It really brought out a part of the subjects' thinking and representation system. I only had three students draw this picture. I wonder how things would have differed if I had asked the entire class to draw this. I also wonder what things would be the same.

IMPLICATIONS FOR TEACHER EDUCATION

The prospective teachers who gathered these data felt their efforts were worthwhile. They learned first-hand about many of the things that Sutton (1989) and others (e.g., McInerney & Park, 1986; Sanders & Stone, 1986) recommend as strategies for addressing inequities in computer use, beginning with the importance of understanding that boys and girls may have different experiences with computers and may think differently about computer technology. For example, the endurance of girls' thinking that technology is a male domain, the influence of male characters in software, and the perception that males have more access to computers are all factors that as future teachers they will need to counteract. As a result of conducting this inquiry project, they understand the importance of equitable access to technology for all children regardless of gender, race, or class and the crucial nature of their own role in providing and monitoring access to computer technology, selecting unbiased software, and serving as role models and computer-using teachers themselves.

The teacher-researchers also gained a better understanding of children's thinking and development, especially of egocentrism in young children, which was an unintended but welcome outcome of this project. Based on concrete examples in the children's drawings and comments they received when asking the children about their drawings, these prospective teachers developed a better understanding of how children's thinking develops. For example, their concept of egocentrism is now much more concrete and no longer just theoretical. One teacher-researcher interning in a Kindergarten class at Georgetown wrote about the inquiry project and egocentrism in this way:

This is an intriguing activity which investigates the way students view computer technology as well as its relationship to gender issues.... It is interesting to note that they all drew themselves using a computer. When I asked the students to explain their pictures to me they each independently pointed to the computer and the person in their drawings and said, "This is the computer and this is me." ... The students seem to display an egocentric perspective on computer technology: They are only able to consider computers as they directly relate to themselves. For this reason, they drew themselves working on a computer instead of someone else. They have not considered computer technology as it relates to other people. Students also regarded the computer as being the same gender as themselves. They play games with characters of the same gender as themselves. Such behavior displays egocentrism which is typical of this age range.

SUMMARY AND CONCLUSIONS

In this study, prospective elementary teachers conducted an inquiry project as a part of their Professional Development School teacher preparation program to learn more about how input and process variables such as gender expectations, SES, access to technology, and female role models influence how children think about technology. Twenty-three preservice teachers, serving as teacher-researchers in a group inquiry project, asked elementary-age children to "draw a technologist" and then interviewed them to learn how children think about the gendered-nature of computer hardware and software and about their access to computers outside of school. A comparison between two different schools showed no difference in the children's responses by race or socio-economic status. However, analyses of the children's drawings indicated several interesting gender differences and developmental trends in children's thinking about technology. For example, younger children drew computers much larger than themselves and set the computers in home or school settings compared to older children who drew the computers in proportion to themselves and placed the computers in school or work-related settings. In the interviews both boys and girls could name software, mainly games, with male characters but only 6% could think of any software with female characters. Differences with respect to access to computers at home associated with socioeconomic status in the two school settings did not materialize in this study, although most girls reported that their fathers or both parents bought and used their home computer the most while one-third of the boys said that they used it the most and that their fathers purchased the computer at home.

That no real differences between the two school sites materialized in this study indicates to us that perhaps the school district's investment in technology at Jefferson is paying off and counterbalancing the data reported in the literature that children from high SES neighborhoods, white males, and children from families who own computers at home have an advantage over minorities, females, and children from low SES areas with regard to computer access and competence (Martinez & Mead, 1988). In fact one of the teacher-researchers who conducted her inquiry at Jefferson drew this conclusion in her analysis:

I think the children realize that computers are used in many ways to help us, but they do not really have a clear picture of what a technologist is. However, they realize the importance of computers and that they can be used in many areas of life. This is really important because they are aware that the resource is there if they need it. That is more than I knew in second grade. They have taken the first step in getting involved in using computers.

FUTURE RESEARCH

Although we did not find differences between the two schools with regard to access to computers at home, we think it is worth replicating this study on a larger scale. For example, it would be interesting to see if our sample is representative of the entire population of these schools and to similar ones in our district. We want to explore the limited findings in this study in more depth by interviewing more children and also members of their families about their understanding of the role of a technologist and about gender issues revolving around computer technology. We would also like to expand our interviews to include the following questions: Where are some other places you see computers other than at school? What are those computers being used for? Do you know people who use computers in their work? What do they use computers for? Do you think you will use computers when you go to work? What do you have to know to be able to use a computer? Does everyone use computers? Why or why not? Are boys or girls better at computers? Why or why not? What are some other forms of technology?

We also want to find ways to further explore the developmental issues around how children think about computer technology. For example, following Turkle's lead, we would like to learn more about how children understand the nature of computers by asking questions such as: Is the computer alive? How do you know? What about trees, rocks, clouds, TV sets, cars, an apple, etcetera? Are these alive? How do you know? Where do computers come from? Does the computer ever cheat when you play games with it? How are computers different from people? We plan to continue using the "draw a technologist" task but we would also like to ask the children to draw themselves using technology based on the "Draw-Yourself-Doing-Science" Test (Matkins & Curtis, 1995) to see if the exaggerations in relative size we found in this study persist and are related to the children themselves as well as to adults.

Adding a classroom observation component to out next inquiry project is also a possibility. For example, during their time each week in the schools, teacher candidates could do some systematic observations of the children using the computers in their classroom and in the computer labs. They could also observe their cooperating teachers' interactions with computers and with the children using the computers. Observing who uses the computer, when, for what purposes, how, and for how long would provide teacher-researchers with additional data to interpret children's experiences with technology in schools and with fodder for reflection about what a teacher's role should be with regard to technology.

Learning to teach and learning to understand how children think must be an active, hands-on process. Orienting teacher candidates to the process of systematic inquiry is one form of pedagogy that we intend to continue in our PDS program at the University of North Carolina at Greensboro. The experience of having prospective teachers act as teacher-researchers and participate in inquiry projects that allow them to learn from the children in their field placements is also something we plan to continue. Following this project, which modeled some ways of conducting inquiry, our prospective teachers have the opportunity to pose their own individual questions for further inquiry and act once again as teacher-researchers during their second year in our program. We believe that teacher candidates benefit from such experiences and can learn to think about teaching and learning, and the process of learning to teach, as a problem solving, inquiry-oriented, and reflective process.

Note:

Figure 1. Note the setting of the computer (outside) and the relative size of the computer compared to the child in this self-portrait. However, also note the affect (smiling) and the level of detail in this drawing.

Figure 2. Note that by 4th grade the relative size of the people and the computers are more realistic in the pictures that older children drew. Also note that the affect portrayed in the drawings remains positive (smiling).

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