Three Important Research Agendas for Educational Multimedia: Learning, Children, and Gender

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ABSTRACT

This paper discusses three often-overlooked characteristics of educational multimedia systems that are important for human-computer interaction (HCI) researchers: (a) learning environments have very different goals and approaches than do workplace environments, so HCI research must investigate issues within the context of learning; (b) what works for adults will not necessarily work for children, so HCI research must develop usability guidelines that are appropriate for children; (c) girls and boys interact differently with technology, so HCI research must understand how each gender interacts with computers. We illustrate each of these issues with examples from our own research and explain how the characteristics of educational multimedia systems can lead to computing environments that do not hinder children's learning and do not exclude any children on the basis of gender.

KEYWORDS

Human-Computer Interaction (HCI), children, learning, education, gender, educational multimedia, interaction styles, games, collaboration

INTRODUCTION

Human-Computer Interaction (HCI) research has primarily been concerned with adult users in the workplace. When investigating HCI issues for the design of educational multimedia for children, it is important to look beyond the existing body of HCI research and re-examine specific issues in the context of learning environments, the needs of children as users, and issues of gender.

The thrust of HCI research is that users should not have to adapt to the technology, but instead, the technology should be designed to support the needs of the users. Historically, computer users have been adults in the workplace, while today users can be any age and encompass many groups within society: male and females, young and old, and all cultural and economic groups, just to name a few. As the definition of user grows, HCI research is also expanding to encompass the wide variety of users interacting with technology. In order to fully understand the needs of these new users, we must also understand the context and the environment in which the systems will be used. It is because of this that new areas within HCI are developing such as Computer-Support for Collaborative Learning Environments (CSCL).

This paper presents three important research agendas for HCI. First, we must recognize that learning environments have very different goals and approaches than do workplace environments, and it is important to investigate issues within the context of learning. Secondly, it is important to look at the differences between adults and children in the context of computers. What works for adults will not necessarily work for children. Finally, it is important that we understand how each gender interacts with computers so as to not exclude any children.

While educational multimedia can be used by a wide variety of people in numerous settings, this paper will focus on educational multimedia for children in a school environment. This paper will present past and present research as well as directions for the future to help in the development of educational multimedia.

LEARNING: WORKPLACE VS. LEARNING ENVIRONMENTS

One of the primary goals for using computers in the workplace is to help improve workers productivity while learning is commonly a secondary goal. In contrast, learning is one of the primary goals for the use of computers in an educational environment. This, in itself, will cause users to view and interact with systems differently.

Usability Guidelines for the Workplace and Learning Environments

Researchers in HCI have developed a set of usability guidelines, and design and testing techniques to help improve the design of products for the workplace [1]. Use of these guidelines for the design of educational multimedia products for children, while perhaps is useful, does not acknowledge the fact that learning environments are often different from workplace environments. Robertson [21] has suggested that traditional usability design guidelines and usability testing methods need to be revamped for educational software.

Productivity vs. Entertainment

One of the most striking differences between individuals in the workplace and children in school is their motivation for using technology. At work, the motivation to use computers comes from the need to complete the task components of a job. While children also use computers to complete a task assigned by the teacher, the real motivation that children have to interact with technology is *enjoyment*. For computers to be effective for adults in the workplace, computers must be easy to use and help the individuals complete their day-to-day tasks. For computers to be effective for children at school, they must be fun. Several researchers have noted the potential benefit of educational software if it facilitates the children's motivation to play as observed when they play electronic games [12, 23].

Collaborating on Multiple Networked Machines vs. a Shared Machine

One example of the difference between designing for the workplace versus the classroom can be seen in the area of Computer-Supported Cooperative Work (CSCW). The premise for many CSCW systems is multiple people, *each with their own machine*, working together towards a common goal. Often, these machines are networked together to support the collaboration. This could be in the form of a meeting support system or a shared word processor. In contrast, in the classroom, where learning is the ultimate goal, often the verbal discussion of ideas and hypotheses is a key component of the learning process. This may be best facilitated when the children are sitting side-by-side, talking face-to-face, both focusing on the same artifact. Therefore, a good approach in designing a Computer-Supported Collaborative Learning (CSCL) tool for use in a single classroom may be to focus on children collaborating on the *same machine*, and deciding how to best support this type of collaboration. Researchers have begun to explore the concept of providing a shared screen with multiple input devices to enable multiple children to work together on the same computer [9, 6, 3].

CHILDREN: ADULTS VS. KIDS

The computers that children use at home and at school for the most part look like the machines that you can see on most desks in the business world. We have taken a product, developed for adults in the workplace, and given it to children for school and play. How do we know that this machine is designed appropriately for children? Most of the software on these computers had been adapted for children but this adaptation has, for the most part, been designed in an ad-hoc manner. Very little research has been conducted on how to effectively design computer software for children. With computers becoming more prevalent in the education system, it is critical that we understand how children interact with computers and the most effective way to design the hardware and software.

Motor Skill Development

Some researchers have noted that children have difficulty performing mouse operations that require sustained pressure on the mouse button [7, 8, 24]. Inkpen et al. investigated two common mouse interaction techniques: drag-and-drop and point-and-click. A preliminary study looked at girls playing two different versions of the same computer game, one which utilized a drag-and-drop interaction style while the other utilized a point-and-click interaction style [8]. This study showed that girls were able to solve more puzzles using the point-and-click version of the game than using the drag-and-drop version. In addition, girls using the point-and-click version of the game were also more motivated to play. A follow-up study examined children moving objects around on a screen using either a drag-and-drop interaction style or a point-and-click interaction style [7]. The results of this study suggested that a point-and-click interaction style was better for children than the drag-and-drop interaction style, based on children's preference, speed, and number of errors committed.

Cognitive Differences

A few researchers have begun to notice that adults' computer interaction styles are not necessarily appropriate interaction styles for children. Berkovitz noted that children have a lot of difficulty stretching a selection rectangle around a group of objects. Children often misplaced the initial point of the selection rectangle and therefore missed some of the objects that they were trying to select [2]. Error in placement of the initial point could be attributed to two causes: 1) the inability of children to understand where the initial point should be placed in order have the box to encompass all of the appropriate objects, or 2) a lack of planning on the part of the children before initiating the action. Berkovitz suggested a selection technique that was more appropriate for children where they could "push out the edges" of the selection rectangle. This improvement not only allowed for the traditional method of dragging the mouse along the diagonal of the rectangle, but also enabled the children to use a circular gesture to define the selection rectangle.

Experiential Differences

These examples show how children have physical or cognitive difficulty using adult interaction techniques commonly found in children's computer software. We also need to be concerned about how the children make sense of the applications they are using. One particular design strategy in HCI is to design products that encourage users to form the correct mental model of a system. This can be accomplished by having the application use metaphors for something that the user is already familiar with [18]. Because children have different experiences and perspectives than adults, common adult metaphors may not make sense to children. One common adult metaphor found in software is the desktop metaphor but, as Jones states [11], this is not an appropriate metaphor for children. Children do not have much experience in office environments with file folders and in-out trays. Instead, child-appropriate metaphors should be used. Jones suggests that the best way to achieve this is through user-centered design [11].

These results emphasize the need to continue exploring HCI issues for children. Children are not adults: their motor skills are not fully developed, their cognitive capabilities are different, and their motivation for using computers is different. If we carelessly develop educational multimedia tools we may jeopardize our children's ability to learn with the tools.

GENDER: GIRLS VS. BOYS

Girls and boys interact differently with computers. Girls and boys think about computers differently, have different motivations for using computers, approach computers differently, have different preferences, and have even shown differences in the ability to use various interaction styles [4, 6, 7, 9, 14, 16, 25]. Because of this, when designing educational multimedia, we must be sensitive to gender issues to ensure that the products developed are appropriate for children of both genders.

Gender Stereotypes in Electronic Games

Earlier research on children interacting in an electronic games environment found several difference between girls and boys [10, 15]. The differences included the types of games the children liked, what aspects of the games were important to them, and to what degree the games were a part of their social environment. Unfortunately, many electronic games are designed by men, for the young male market. Gender prejudices can be found in many electronic games that involve violence and use women as "objects" to be rescued [20]. This in itself is a major problem because often, electronic games are often a gateway for children to become involved with computers [19]. Not only is it important to develop products that are appropriate for both genders, it is imperative that the products developed do not promote the negative stereotypes of either gender.

Complexity of Gender Differences
Research must be conducted in order to begin to understand the complex nature of gender differences. Previous research had shown that software designers incorporate their own gender biases into the software that they develop [5]. Often, these gender biases will cause the designers to miss important subtle nuances with respect to gender differences. For example, a math prototype game was developed for girls and boys. When playing with a partner, two modes of play were available: *compete* mode and *team* mode. Before presenting this game to children, researchers assumed that girls would prefer to play in *team* mode and boys would prefer to play in *compete* mode. The game involved having a frog hop around on lily-pads according to a mathematical problem. In *compete* mode, each partner had their own frog and their own score. In *team* mode, there was only one frog and both partners contributed to a single score. When the prototype was presented to children, the developers realized that their intuitions were wrong. The girls preferred to play in the *compete* mode because they could each have their own frog. For girls, the sense of identity, and character was important. Boys, on the other hand, preferred to play in *team* mode because they recognized that if they worked together, they could get the highest score in the whole class! Even though the boys were competitive, they were willing to cooperate with one person in order to have a higher level of success and compete with the rest of the class. This example demonstrates that the gender differences exhibited in a computer environment can be complex and easily misunderstood without proper research.

Gender Differences in Collaborative Environments
Qualitative, anecdotal observations are useful but quantitative data may also be required to sort out gender differences. Quantitative data on children's collaborative behavior was collected in a study which involved children played a puzzle-solving game in various collaborative set-ups [9]. The collaborative protocols included pairs of children playing the game with either one *shared* mouse or two mice. In the two-mouse conditions, two protocols were used to transfer control between the mice: *give* and *take*. In the two-mouse *give* condition, the partner in control of the game cursor would press their mouse button to pass control of the game cursor over to the other partner's mouse. In the two-mouse *take* condition, either partner could take control of the game cursor by pressing their right mouse button at any time.

The results from this study revealed that girls solved more puzzles in the two-mouse *give* condition than in either of the other two conditions. While the number of puzzles that boys solved in the various conditions was not statistically different, further analysis of boys sharing patterns revealed that boys exhibited quite different behavior in the three conditions. In the two-mouse *take* condition, boys demonstrated a more equal distribution of mouse time between the two partners than in the other two conditions. In addition, a correlation was found between how long each boy had control of the mouse during a collaborative session and how well they could perform later on their own. If our goal is to have all children benefit from the collaborative session, then an equal distribution of mouse time would be advantageous.

It is important that we continue to explore how both girls and boys interact with computers and ensure that all of our HCI research is sensitive to gender issues.

ADVANCING THE AGENDAS

The three research agendas presented here, namely, learning environments, children, and gender all converge into one common focus: user-centered design. In order to design effective educational multimedia we must understand how children of both genders interact in a learning environment.

The project group E-GEMS (Electronic Games for Education in Math and Science) at the University of British Columbia and Queen's University is employing user-centered, participatory, design as its main research approach. Prototype educational games are being developed and tested with students in four elementary school as key participants in the design [13]. The E-GEMS classrooms (three in Vancouver, British Columbia and one in Kingston, Ontario), have each been equipped with four Macintosh computers. The teachers and students in these classrooms test out the prototypes and give valuable feedback. The children's feedback involves not only what they like and don't like about the game but also suggested improvements or enhancements. Beyond designing and testing games, E-GEMS is also examining how to incorporate educational electronic games into the classroom and the curriculum.

E-GEMS researchers also spend a great deal of time in elementary schools either having children try out their ideas or conducting studies on old or new interaction styles [6, 9, 22]. In addition to elementary schools, E-GEMS researchers conduct research at Science World BC, an interactive science museum in Vancouver, British Columbia. By constantly working with children, the E-GEMS researchers and designers are always putting the needs of children first, and are always trying to better understand these needs.

Research on how to effectively design and use educational multimedia in a learning environment, for girls and boys, has still only scratched the surface of the iceberg. Continued research is needed, with the emphasis on user-centered design. Merely creating educational software and placing it in front of children is not enough.

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