INFORMATION TECHNOLOGY FLUENCY FOR MIDDLE SCHOOL GIRLS

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Abstract

To participate in the changing world of technology, students must develop information technology (IT) fluency, rather than simply IT literacy. Fluency includes three kinds of knowledge: skills, concepts, and capabilities. The acquisition of these kinds of knowledge is more likely to happen in the context of project-based work. Because of the continued majority of males in IT, it is essential that efforts are made to increase the participation of girls. In this paper, we describe an after school program for middle school girls that aims to develop IT fluency by teaching them to make computer games. We present data from their games that show how participants have made substantial strides toward information technology fluency. The findings suggest that most girls developed skills in graphics, use of a database, and the use of the internet. They developed capabilities such as sustained reasoning and managing complexity. And they developed concepts such as algorithmic thinking and programming and information organization.

Key words: information technology fluency, pair programming, middle school, collaboration, project-based

Introduction

Information technology (IT) fluency requires three kinds of knowledge and the acquisition of these kinds of knowledge by the use of project oriented work. We will show how middle school girls participating in an after school program involving the use of pair programming to create interactive 'choose your own adventure' games have made substantial strides toward IT fluency.

A program focusing on fluency and not just skill acquisition is important for both male and female students to succeed in the changing world of technology. A fluency model includes a broader framework of interacting with computer technology that is especially beneficial for girls. Girls need to be able to discover and pursue their own role with technology-related tasks and interests. The inclusion of concepts and capabilities in addition to skills provides us with insight into how girls can be more successful in pursuing interests in computer technology.

In our program, creating interactive computer games provides the participants the opportunity for an active role in relation to the computer, improves spatial and problem-solving skills, and acts as a gateway into careers in technology [1,2]. Currently, computer games are primarily produced and played by males [3]. To increase girls' involvement in technology-related fields, our program focuses on girls producing their own interactive computer games [3]. We describe our program and explain what we mean by IT fluency and the three IT fluency knowledge areas of: skills, concepts, and capabilities. We then provide examples of IT fluency acquisition measured from our program.

Program description

Girls Creating Games is an after school and summer program for 6th, 7th and 8th grade girls designed primarily to increase their interest, confidence and skills in computer technology. Education Training Research Associates (ETR) was funded by the National Science Foundation's program on Research on Gender Equity in Science, Technology, Engineering and Mathematics to develop and implement the research-based program. Six implementations were completed over the course of two years. Two of these implementations were during the

summer at a local Boys and Girls Club. In the after school program, participants met twice a week for two hours for a total of twelve weeks. The project-based program focused on the design and construction of interactive narrative computer games using Macromedia Flash MX – a web-based multimedia software program.

Typically, middle school students are taught computer or information technology literacy-related tasks. But increasing girls' skills or literacy is not enough to increase their role in producing technology [1, 4] The Girls Creating Games program makes a unique contribution because it teaches information technology fluency rather than just IT literacy.

To help the girls design their games, participants played other computer games to generate ideas, brainstormed story ideas, wrote their game story on paper with different choices of which paths to take for different outcomes, and took notes on ideas they had. They then started constructing their games on the computer. They often went back later in the project and modified parts they had designed earlier to match how their game design had progressed. Throughout the building phase, participants showcased their games, received feedback on how they could make it better, and identified "bugs" they needed to fix. The participants used fifty percent of the program time to learn how to use the Flash software and to design, program, and debug their games. The other half of the program time was spent in team-building, career exploration, and self-reflection activities. Our program participants worked as "pair programmers" through all of the stages of game development and building both on and off the computer [5]. In our program, typical of any pair programming partnership, girls worked together side-by-side at a single computer and gave each other support. One girl was a 'driver' who operated the keyboard and mouse, and the other girl was a 'navigator' who made decisions collaboratively with the driver. An additional role of the navigator was to watch what the driver was doing and look for potential problems. Throughout the time working on the computer partners switched roles. Most of the participants worked with a partner the entire implementation (85%). The remaining participants either worked alone (6%) or started with a partner and finished alone (9%).

This paper reports on data from a total of 33 games completed during the third, fourth and sixth implementation cycles (after school only, not summer).

IT literacy vs. IT fluency

Information technology (IT) fluency has been proposed by the National Research Council (NRC) as a minimum standard for college graduates [6]. This proposal states that IT literacy, or knowledge of the skills needed to use today's computer software applications, is insufficient to use the computer software applications of the future. Because information technology is rapidly changing, the skills that are necessary to use today's computer software will need to be updated for the future. Our students need more than just skills to use current programs such as web browsers, email, and word processors. Instead they need to adapt those skills to use 'as yet developed' software. Therefore, being fluent in IT starts from the point of IT literacy and brings the person into a position to be able to adapt as IT changes. It is important that IT fluency "should not be regarded as an end state that is independent of domain, but rather as something that develops over a lifetime in particular domains of interest and that has a different character and tone depending on which domains are involved. Accordingly, the pedagogic goal is to provide students with a sufficiently complete foundation of the three types of knowledge so that they can "learn the rest of it" on their own as the need arises throughout life" [6]. This 'sufficiently complete foundation' is a proposed standard for college graduates [7]. The NRC's report suggests that IT fluency education should be part of K-12 education but does not contain guidelines for K-12 education [6].

The NRC bases IT fluency on three aspects of knowledge: skills, concepts, and capabilities. IT skills are seen as today's literacy. The conceptual basis of IT is independent of current technology because the information technology of the future will be based on the same conceptual basis as the current technology's basis. Many of the intellectual capabilities for IT are familiar from other domains such as engineering and general education, and are also seen as important for information technology. Each list has been prioritized and only the top ten items in each knowledge area have been named by the NRC [6]. (See http://stills.nap.edu/html/beingfluent/es_b1.html.)

IT fluency competence and the girls' games

In the next sections we detail examples of our mapping from aspects of IT fluency knowledge areas (e.g., NRC IT fluency skills, concepts, capabilities) to Macromedia's Flash features included in the participants' games. Before we provide this mapping, we argue that, if one of these identified Flash features is used in a game at or above our defined threshold level of three, the authors of that game have gained knowledge or have achieved a state of competency in the corresponding IT fluency aspect. We use our threshold level throughout the rest of this paper when reporting percentages. This threshold level is defined by the presence of three or more occurrences of a Flash feature in a game that maps to the identified IT fluency concept, capability or skill. We base this threshold of three upon the following: the first time students use a specific Flash feature in their game the instructor could have walked them through the steps; the second time it is used suggests the students probably understood it without the assistance of an instructor, but we can not be completely confident; the third time we assume they did not need the assistance of an instructor and at that point have repeated it enough times to show mastery of the use of the feature. If mastery is achieved, then we argue that the corresponding IT fluency skill,

concept, or capability has been acquired. In the following discussion we will show that many of the programming pairs acquired many aspects of IT fluency.

IT fluency skills or "literacy"

The NRC proposes a set of generic skills that an IT literate person possesses. In the Girls Creating Games program, participants used Macromedia Flash – a web-based multimedia software program to program their interactive computer games. Our findings show that participants acquired several of these skills. Outlined below are three of the NRC literacy skills with corresponding Flash features that we have identified as being representative of each of these skills.

One of the IT fluency skills is to use an artwork package to create images. Macromedia has an extensive artwork package that includes a drawing and text tool palette; properties panel to manipulate different properties of a selected item; timeline to control the animation of objects; and database "libraries" that store and organize graphics, sound and animations. We have mapped the following Flash features in the game to the skill of using an artwork package to manipulate images: text; clipart; drawings; original or modified buttons (pre-made movie clip animations); sound; animation of text or images. All of the games (100%) reached the threshold level with the inclusion of text and required buttons to link scenes. Data from 91% of the games showed that participants acquired the skill to use an artwork package to create images. These participants reached a state of literacy by the inclusion of one or more of the following: clipart, drawings, modified or original buttons, sound, animations. Additionally at the threshold level, 82% of the games included clipart (placed and usually resized) and 45% had original drawings by the programming pairs.

Another IT fluency skill that we mapped to Flash features included in the participants' games is the use of a database to access information. Flash has databases called "libraries" where graphics, animations, and sound files (i.e., symbols) are stored and organized. These items and their corresponding item types are stored in these libraries. These items can be sorted and organized in folders within the libraries. Flash users are given "Common Libraries" and may use items from this database (buttons, clipart, sound) in their game. Once items are placed in a game, they reside in their own game's "Library." Any symbols created by participants or imported from other places (e.g., Internet) are also stored in that game's Library. All of the participants' games have buttons taken from the Common Libraries. Additionally, 64% of the games had examples at the threshold level of clipart and/or sound from these same libraries. We found that forty-two percent of the games have at least one of the following features at the threshold level: modified or original buttons (color changed, sound added, created from original drawings or clipart), original drawings, animations. The participants who created these games had to create, name, and access these items in their games' Library – a step beyond accessing the Common Libraries.

The last IT fluency skill we have mapped from a Flash feature used by the participants in our program is the use of the Internet to search for information. Participants downloaded clipart or photos (used as a still image or for an animation) and sound clips (for buttons or Flash movie). At the threshold level, 64% of the games included clipart, photos and/or sound found on the Internet. Participants primarily used the Google search engine to locate websites or banks of images.

IT fluency capabilities

Beyond achieving computer "literacy" by the acquisition of skills, the girls also achieved some IT fluency capabilities. For example, all of the participants engaged in sustained reasoning, one of the IT fluency capabilities. The NRC stated that 'sustained' refers to days or weeks rather than a one-time only event. Participants in the Girls Creating Games program worked for twelve weeks designing and constructing an interactive 'choose your own adventure' web-based computer game. Built into the Girls Creating Games program was an approach designed to encourage participants to develop the capability to solve their own problems. While working on their games, all of the girls had repeated opportunities to define a problem and attempt solutions to the problem. We see from the 33 games, completed over the course of 12 weeks, that all participants engaged in sustained reasoning to successfully complete a working game.

We have mapped the IT fluency capability of managing complexity to Flash features used by the participants in their games. The NRC defines this capability to include a sustained activity that involves planning a project, designing a solution, making sure all the components work together, responding to unexpected happenings, and identifying what has to happen with each task. The fact that all of the participants completed games shows that they managed complexity related to the story path structure of their games. Participants were provided with an example on paper of the standard structure of their game including a minimum number of distinct screens and links. Forty-five percent of the games' had structures that were extensions of the minimum requirement. We understand this to mean that these game creators managed complexity to accommodate their own design considerations. Examples of these variations are: a binary tree story path, three additional screens prior to the start of the story asking the player if they "really" want to play the game, a "gallery" of images outside the story line, and the addition of links to have the story paths intersect one another. Only one pair of participants did not complete the minimum structure. Observations of this pair indicate that this was because they were "re-paired" with new partners partway through the program, and

therefore had to re-construct parts of their game with the limited time allowed to complete their game.

The creation and use of Flash animations is another example of managing complexity. Thirty-six percent of the games included animations of drawings, clipart, photos, or text at the threshold level. Flash programmers can create animations by using a frame-by-frame (create the image in every frame) technique or by 'tweening' (create the image in the starting and ending frames and then Flash fills the frames in between). We saw the participants use both of these techniques. Examples include one word of text shape 'tweening' (i.e., morphing) into another, a detailed alien with moving tentacles and rolling eyes, and alternating backgrounds behind a body of text. Creating an animation requires the understanding and execution of choosing how and at what speed the image will change over time. A fairly complex series of steps is required to successfully create a Flash animation. Participants, with help from written support documentation, partners, and instructors, created successful animations.

IT fluency concepts

We also found examples of how participants acquired IT fluency conceptual knowledge. This is defined as knowledge that can be used beyond current technology because the information technology of the future will be based on the same conceptual basis as the current technology's basis. This conceptual basis is perhaps the most intellectually challenging of the three aspects of IT fluency knowledge. Education standards for K-12 typically focus on IT literacy (referred to here as fluency skills) not concepts [8]. Many of the IT fluency capabilities are those needed for a productive life and are not necessarily unique to IT. However, for IT fluency concepts, we see many items from this part of the list as topics from typical university courses such as the Introduction to Computer Science course, cmps010, at UCSC [7, 9].

One aspect of IT fluency knowledge that developed in the Girls Creating Games program is algorithmic thinking and programming. Algorithmic thinking is fundamental to understanding how IT works because computers execute computer programs composed of instructions implementing an algorithm. Flash has an embedded Java-like programming language called ActionScript. All of the games that were created by the participants included ActionScript instructions far beyond our threshold level to alter the path of execution. Further, participants' competence was indicated by their use of ActionScript to control music or manipulate input variables in 33% of the games.

Lastly, participants' games provided data on girls' acquisition of the NRC IT fluency concept of information organization. This includes structuring, classifying, retrieving, and accessing information. This was apparent in the creation and management of layers in the game files, and management of designer-created symbols. Layers are how a Flash user organizes and accesses different pieces of their game. For example, many participants used photos to provide a background in their game and had to solve the problem of having it not overlap text or clipart by placing it on the bottom layer. To manage this, participants were encouraged to name their layers in ways that would be easy to identify. Many of them used terms that anyone could understand (e.g., drawings, buttons, text) while some used their own coding (e.g., b1 for button on the left, b2 for button on the right). When investigating the working game files, 61% utilized the layers to a great extent (e.g., had information sorted on different named layers).

Additionally, examples at the threshold level of symbols that participants created (e.g., original or modified buttons, animations) in 42% of the games exhibit participants' competence in information organization. The manipulation of Flash symbols (described more in the previous section on IT Fluency skill or "literacy") requires that the game designer know where within the Flash program they are working as they move in and out of the symbol editing mode (with its own set of layers) while creating the symbol.

Conclusions & future work

Our program description and quantitative results indicate that the Girls Creating Games program provides opportunities for the acquisition of IT fluency skills, capabilities, and concepts. All of the games exhibited that participants were able to successfully use the provided artwork package, and in more than 80% of the games, participants' went beyond the basics to include additional features. All of the games had examples that show participants' use of the Flash database libraries for buttons, sound, or clipart. Additionally, almost half (42%) of the games included items the game developer created, stored, and accessed in another library. The presence of Flash's programming language to control actions in the games was evidence that all participants engaged in the concept of algorithmic thinking and programming. All of the games confirmed participants' ability to manage complexity by constructing multiple screens and links that worked together. Additionally, 36% of the games included custom animations and 45% had a modified story path structure. Named layers with different features residing on each in 61% of the games indicated that participants were able to organize information.

We are currently working on a more detailed description of all of the aspects of IT fluency knowledge (skills, concepts, capabilities) our participants have acquired. The goal is to include specific aspects acquired while creating the Flash games, with the addition of aspects acquired while participating in other Girls Creating Games program activities that were used to support participants in the creation of their games. Given that the NRC IT fluency report does not identify characteristics for K-12 in their model, the examples from

our Girls Creating Games program can serve as a potential basis for a K-12 model of IT fluency.

Although the findings presented in this paper advance the study of computer fluency, they are based on a small sample of girls in one school, and may not be generalizable to all middle school girls in the U.S. Next steps could include testing this model with a larger group of students, both girls and boys, in different types of schools. Another next step would be to apply this method of measuring fluency to data besides games, such as websites.

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