EMPOWERING MIDDLE STUDENTS TO BE TECHNICAL DESIGNERS THROUGH AN INTERGENERATIONAL PARTNERSHIP

Sanethia Thomas, Jessica N. Jones, Christina Gardner-McCune and Juan E. Gilbert
University of Florida

Abstract

This research presents strategy for broadening participation in computer science by empowering middle school students to be technical designers through an afterschool outreach program. An intergenerational partnership was formed between 12 graduate students and 12 middle school students who worked together to improve the design of 6 educational technology prototypes developed by graduate students during their Educational Technologies course. The researchers conducted training sessions on basic user interface design principles and leveraged several best practices within participatory design methods. Middle school students learned about user interface design, participated in design activities, and generated ideas to improve the design interfaces of the existing projects. Findings show that middle school students believe that designing usable interfaces is a good technical skill to have. Additionally, the graduate students favored the design recommendations given by the middle school students and viewed the middle school students as effective collaborators. This research concluded that participatory design methods offer a strategy to expose students to STEM and involve graduate students in mentoring middle school students to design effective and engaging educational technologies. This paper will give an overview of design training and activities the middle school students received. A description of the projects and participatory design techniques will be included. A discussion of the challenges and lessons learned will be presented and conclude with results and overall perceptions of technology design methods.

Keywords

Computer Science Education; Broadening Participation; Participatory Design; Intergenerational Teams; Design and Evaluating Technologies;

Introduction

User Experience (UX) and User-Centered Design (UCD) are methodologies that have become the central competitive factor of product development across markets. These fields are best practices in which end-users influence how a design takes shape [1]. Involving users through UX is becoming the standard for improving the usability, accessibility, and desirability of the product for the user. Within UX and UCD, users are typically consulted during requirements gathering and usability testing phases. To delve further, participatory design is a methodology that involves the end users in the part of the design process[2]. This methodology aims to bring users into the creative process and provide materials for them to express their ideal solutions. Using participatory design allows the users' voice to be heard at the time of development.

Figure 1 Participatory Design collaboration with graduate and middle school students

Adding the element of involving the children's voices in a more authoritative role can greatly impact the solutions that are designed for them[1]. Children are capable of providing interesting ideas and useful feedback during the design process[2]. Therefore, there must be a change in the traditional standard of a working relationship between adults and children: the students become the designer, and the adult takes on the role of the user[3]. There are many different participatory design techniques that strengthen the process of changing technology. This study focused on low-level prototyping, storyboarding, and obstructed theater.

The researchers incorporated a participatory design curriculum within an afterschool program, Tech Edge. They met with the middle school students for one hour a day to teach computing and user interface design principles and trained the students on how to become effective designers via several weeks of brainstorming activities, creative thinking exercises, and reciprocated feedback sessions[4]. They collaborated with graduate students from a nearby university who created educational technology resources in their Educational Technologies course. There were six projects, and each project had a certain aspect of the technology that needed to be redesigned. After middle school students evaluated each project, they presented a brief summary or presentation of their ideas for a new design.

Thorough analysis from observations, logs, and surveys allowed the researchers to draw conclusions about the participatory design sessions. Students showed that they had the capability to learn advanced design methodologies that are used within the human computer interaction (HCI) community. Additionally, there is a mutual benefit to having graduate students and middle school students collaborate on developing educational technologies. This research paves a pathway to understand how to create new technologies with children as design partners.

Related Works

Historically a child's role in designing new technology has been minimized[1]. However, more recently there has been a growing body of scholarship that includes children as design partners. At the Human Computer Interaction Lab at the University of Maryland, Allison Druin leads an intergenerational, interdisciplinary design team. Researchers work with children on projects to create new technologies. A central theme of their research revealed four main roles that children can play in the technology design process: user, tester, informant, and design partner. Although

the team is focused on developing new technology, they are also focused on developing the child. Druin[5] states, "We have a chance to change technology, but more importantly we have a chance to change the life of a child. Every time a new technology enables a child to do something they never dreamed of, there are new possibilities for the future[5]."

Engaging children and valuing their input develops, empowers, and validates them as an intricate part of the design process[6]. Incorporating intergenerational teams into programs introduces new computer science attributes to children who would not have otherwise been exposed. In addition, creating an intergenerational team aids the cognitive development of the children and shapes their perceptions for future work in computer science[7]. Although the focus is on technology design, concurrently the child will increase their skills related to computer science.

At the Center for Shared Decision Making and Nursing Research, children were integrated as design partners in the development of the software system PedChoice. PedChoice was designed to support pediatric cancer symptom assessment and management. Through participatory design techniques, they explored the roles of how healthy children can appropriately play to inform the design of a system for children with cancer. Experts found that the children are valuable contributors as testers, informers, and design partners to aid in improving software[8].

Methodology

The Tech Edge after-school program met at a local community center. There were thirteen students - ten girls and three boys. The majority of the students (10 out of 12) were African American, two were multi-racial, and one was Caucasian. The students met Monday-Thursday, one hour a day for fourteen weeks. During the first part of the program the students were introduced to basic coding principles using Scratch, an introductory coding program. Then the students engaged in various activities that helped them design according to user interface design principles[4]. The activities were focused on brainstorming, creativity, critiquing, receiving feedback, and evaluation. For the second part of the program, graduate students led participatory design sessions for each of their projects. Table 1 lists the educational technology projects and the associated participatory design activity. All Tech Edge students participated in each of the graduate student projects.

For the first project, middle school students used construction paper and markers to redesign the interface of an aviation system. The second project implemented the concept of obstructed theater, a new design technique that incorporates children performing skits about a particular design interface[2]. The students were shown a video clip of how a design interface of an interactive short story was supposed to work. They were given the 3D model prototype and were then tasked with creating a short story about how they would use the model. They worked in groups and used storyboarding to develop each scene and created props with bags of random items to add to the scenes of their stories. For the third project, the students were shown a poster-sized depiction of an intelligent tutoring system and were tasked with drawing the system's navigation icons. They were given bags of random items, including colorful sticky shapes, markers, scissors, glue sticks, and colored construction paper[2]. For the fourth project, the students interacted with an online textbook and were asked to redesign the background and the avatar. They were given construction paper and markers. For the fifth project, the students were

given watercolor paint to illustrate their ideas about the theme of a musical on construction paper. They were given a short story about the interface and were instructed to listen to an audio file of music and interpret what they heard through painting. For the sixth project, the students were shown the current state of the interface for a math software program and were tasked with drawing a background for that interface. This project incorporated technology in order to add an element of design to break up the monotony of using construction paper and hand drawings. The students were able to use Microsoft PowerPoint to illustrate their designs.

Graduate Students Educational Technologies and Participatory Design Activities		
Project Name	***Project Description***	***Participatory Design Activity***
Aviation (1)	This project is a test prep software application geared to helping those interested in taking the aviation aptitude test.	Redesign the background of the technology interface.
CyberPlAYce (2)	This project is an interactive computational construction kit for elementary students.	Re-create 2D and 3D prototypes of the panels and interacted with storyboarding.
Site Word Pal (3)	This project was designed to help lower elementary students learn how to read and spell.	Redesign the buttons on a web application.
Interactive Notebook (4)	This project focused on making history more interesting through the creation of an electronic textbook.	Redesign the homepage of an interactive textbook and design an Avatar.
Warm/Cold Colors (5)	This project helps students learn about warm and cold colors through drawing, teaching the students creative disciplines using computer technology and art.	Redesign the interface of an application that identifies warm and cold color paintings from musical selections.
Vedic Math (6)	This project is a web interface that was created to teach math tricks for solving complex two digit multiplication problems easier.	Redesign the interface and background.

Results

Middle School Student Perceptions

Data was collected using pre and post surveys from the students. Interviews were captured through video and audio recording and on occasion, computer recording software. Daily logs, observations, and fields notes were coded to provide insight on the students' behaviors as they completed the activities. The results from the survey revealed that all of the students (N=13) agreed that Tech Edge offered activities that they had enjoyed. More specifically, 76% of the students believed that designing technology is an important skill to have. When asked what they liked most about Tech Edge, one student said, "We got to do different things it was fun to do,

and you learned different things with engineering and design." Other student comments were, "It was fun!" and "I like the lessons on designing."

Initially, the students seemed excited to work with the graduate students on their technology projects. The post-survey revealed that 83% of the middle school students enjoyed the sessions. One student commented, "What I like about the program is to see our ideas elevate up and used." Another student said, "I liked to test out all the games and they do experiments on us. I like the activities we can do while observing what they are trying to teach us."

There were several students who shared their feelings of the sessions being "boring." One student expressed her frustration using the same materials to create designs. Some of the participatory design activities were redundant and the students had become fatigued and bored.

Our program showed statistical significance with our P-value less than .0001. With N=35, our hypothetical mean was 5 and our actual mean was 3.51. The standard deviation is 1.96.

Graduate Student Perceptions

The graduate students felt that it was rewarding to work with the middle school students and five out of six projects were redesigned using the middle school students' suggestions. 88% indicated the sessions were useful to their project. The graduate students reported that the activities were useful for understanding how middle school students think and what interests them. One graduate student said, "The responses given to us by middle school students were helpful to understand their likes and dislikes and we were able to understand their thinking process, and working with them helped me to understand what students expect from technologies, especially websites that they use." Another graduate student indicated, "The feedback given to us by the students helped us in shaping our project and making it more likeable. It helped me see how good and bad my design was." When asked what they would do differently one student said, "Use more children-friendly ways, avoid jargon and professional terms." Another student stated, "I would give children shorter and more precise tasks."

Lessons Learned

Design Materials

There was lack of variety of the participatory design methods. Five out of the six projects contained some aspects of having the students draw. After the third participatory design session the students were fatigued and tired of drawing. The researchers shifted from having the student draw by hand to having them draw on the computer using Microsoft PowerPoint to increase their interest and engagement. This was particularly helpful for the students who were not good at hand drawing.

While providing students with a wide variety of design materials can help foster creativity and inspire them to think outside of the box, many of the items became a distraction and impeded the design process. Giving students a lot of materials caused them to be distracted and playful. For example, two of the boys in the program spent their time putting the sticky shapes on themselves and each another. The students had to rush to finish their designs towards the end of the hour because of their playfulness. When considering items for the participatory design activities

carefully plan the materials being used to avoid the risk of distraction that could hinder their creativity.

Work Space

There were many environmental challenges that stifled creativity. The work area was dull, bland and boring. There were long tables and folding chairs that resembled a school cafeteria. The space was small, restrictive and the lighting was dim. The environment put a damper on the students' mood and it was a challenge to motivate students to participate. After being in school all day, the students were restless and eager to go outside. Prior research on participatory design sessions suggests that children are empowered when they feel in control of their environment and when they feel they "own" the environment[2]. Unfortunately the space was rented, and there were minimal changes made to create an environment that was conducive to spark creativity. Students had input into the layout of the room, but space constraints limited the number of configurations into which the room could be arranged. Students were not allowed to decorate or utilize any other methods to make the space feel as if it were their own.

In the future, it is suggested to create and kid-friendly space by using bright and colorful posters and giant stickers or wall art created or selected by students. Replace the hard steel chairs with comfortable seating such as beanbags or soft carpet. Break the space in different stations or work areas so that each area has a theme: computer station, homework station, designs station. Explore using various tools for drawing such as using the computer for enhanced creative expressions or having templates to generate ideas or to trace from.

Training for Graduate Students

For some of the graduate students this was the first time they worked with middle school students and they felt a bit awkward. It will be beneficial to provide training for instructors on how to work with children. Sample training sessions would be on classroom management, nurturing the creativity within children or keeping children engaged throughout the process.

Conclusion

With technology being involved in every aspect of society, having middle school students exposed to designing technology gives them the benefits of computing at an early age. Engaging children and valuing their input develops, empowers, and validates them as part of the design process[5]. During the program the middle school students had the opportunity to work directly with graduate students and were given hands on experience to design educational technologies.
Having a participatory design model is beneficial to both the designer and the child. Children's ideas should to be included throughout the entire technology design process and they should be considered equal stakeholders in the design of new technologies. An intergenerational team aids to the cognitive development of the children and shapes their perceptions for future work in computer science[7].

There was an overwhelming response of success and enjoyment for computer science among the middle school students. Incorporating an intergenerational team into a program introduces computer science to middle school students from those whom they tend to admire. It gives them an opportunity to work with college students and encourages them to have an increased interest

in computer science and possibly pursue a computer science degree. It also provides an opportunity for graduate students to participate in outreach opportunities to help increase participation in computer science.

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Sanethia Thomas

Sanethia Thomas is a PhD Student, a National Science Foundation (NSF) Graduate Research Fellow, and GEM fellow at the University of Florida in the Human Experience Research Lab under Dr. Juan Gilbert. She has a bachelor's degree in Information Technology from the University of Texas El Paso and a Masters in Youth Development Leadership from Clemson University. She has experience in the private and public sector, from America Online (AOL) to Government and to K-12. Her research focus touches areas in User Experience, Human Centered Computing, Educational Technologies, and Athlete Development.

Jessica N. Jones

Jessica N. Jones is a Ph.D. student at the University of Florida studying Human Centered Computing in the Department of Computer and Information Sciences and Engineering. She received her B.S. in Computer Science from Hampton University in 2011 and her Master's Degree in Computer Science from Clemson University in 2014. Her research interests include educational technologies, robotics and natural interaction.

Christina Gardner-McCune

Christina Gardner-McCune is currently an assistant professor at University of Florida. She has a B. S. degree in Computer Engineering from Syracuse University, and earned both her masters and doctorate in Computer Science from Georgia Institute of Technology with specializations in Software Engineering and Learning Sciences and Technology. In addition, she completed a postdoctoral research position in Computer Science Education at Georgia Institute of Technology.

Juan E. Gilbert

Dr. Juan E. Gilbert is the Chair of the Computer & Information Science & Engineering Department at the University of Florida where he leads the Human Experience Research Lab. He is also a Fellow of the American Association of the Advancement of Science, National Associate of the National Research Council of the National Academies, an ACM Distinguished Scientist and a Senior Member of the IEEE. He received his B.S. in Systems Analysis from Miami University (OH) in 1991 and his M.S. and Ph.D. degrees from the University of Cincinnati in 1995, 2000, respectively.