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IMMERSIVE LEARNING: DEVELOPING AN INTERACTIVE TOUCH SCREEN LEARNING MODULE FOR CHILDREN WITH AUTISM

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ABSTRACT
Design and Engineering have truly reached a point of convergence. With the growing complexity of project deliverables, expanding technologies, and more diverse and discriminating audiences, we've reached a point where collaboration through immersive experiences is required. Often times, the constraints of an academic term, either quarters (10 weeks) or semesters (14–16 weeks), do not allow for full immersion into a project. Nor does it offer the opportunity for students to fully realize roles and responsibilities or the necessary behaviours for successful collaborative.
Our goal was to structure a long term, in-depth collaborative study environment that would facilitate rigorous research, discovery, and outcome. This one-year group study enabled the student participants to understanding the process of designing an interactive experience at a holistic level. It furthered the idea of collaboration and allowed time to deliver a project beyond a speculative composition to a fully functional application.
Our project goal was to develop an interactive application that enabled autistic children to practice communication and social interaction. Our interdisciplinary team of graduate students developed a touch screen application that facilitated the learning of word and picture associations. This paper will outline the interdisciplinary process utilized in the creation of this application and the rationale supporting its development. Key to the success of this application was the collaborative make-up of the design team, the duration of our experience, and the collaboration with software engineers, therapists and autism researchers.

Keywords: Touch-screen, co-participation, interaction, learning module, collaboration, immersive experience

1 INTRODUCTION

For some time, the Department of Design at The Ohio State University has encouraged interdisciplinary design activity as a means to solve complex and multifaceted problems. Students have worked in a collaborative environment with project constraints often dictated by the course instructor. These experiences are valuable and important to our students, but the project deliverables at times lack depth, do not provide for problem definition from the students, and results in a concept that can only be presented as conceptual or speculative. Given the constraints of an academic term, it is difficult for students to fully realize all the phases required in developing meaning outcomes beyond non-functioning prototypes.
To overcome this concern, we have recently structured graduate level - small group study where students work through a complex problem for the duration of an entire school term… in our case 30 weeks. The goal is to provide students with broad, hands-on exposure to interdisciplinary design experiences that include problem definition, research, conceptualization, design, user testing, and development.
For the inaugural sequence of courses at my institution, I formed an interdisciplinary team of graduate students who all had a common interest in interactive media. The group of students had various levels of formal training, skill, and competency. I organized the experience into three – 10 week modules, 1) problem definition and ideation, 2) design, prototyping, and usability testing, 3) enhancement and development. The only content requirement was that the team was to work in the area of touch screen

interaction. This requirement was determined based on my research agenda and expertise, but may be defined across many different domains.
The first step in our experience was to collectively define our objectives, identify a problem, and to research what content would be most appropriate. Giving the students this task was important so they would feel fully vested in working on a project for an extended period of time. Through a series of brainstorming exercises, the students eventually committed to developing an interactive, multi-touch learning module to assist children with autism.
There are several beneficial outcomes when structuring a long term, interdisciplinary group study such as this. By reducing the boundary of time, i.e., a semester, the instructor is enabled to expose students to a broader set of concepts corollary to interdisciplinary experiences. In this case, we were able to include study in HCI, Software Engineering, Instructional Design, and Cognition. It also affords the students a better understanding of the related domains, therefore making them better equipped at delivering holistic solutions. And perhaps most meaningful to the instructor, the process aids in building a more in-depth knowledge base on the particular topic being studied, and in this case, the necessary requirements in developing multi-user, touch screen learning modules.

2 WHY TOUCH?

Touch as a source of input has become a more important concern for design and engineering practitioners, theorists, and students. With the proliferation of touch activated devices such as Droid Phones and iPads there is an ever-expanding palette of interaction models. When examining the origins of touch, its intrigue is clearly evident. The concept of touch has origins dating back to the 13th century. It was defined as to knock or to strike something. In the 14th century it was theorized that touch had connections to emotions. Our sense of touch gives us cues from our environment from which we can learn about our surroundings and ourselves [1, 2, 3]. It's how we know if an item is too hot or too cold or if it will cut or scratch [3, 4]. It gives us feedback on the appropriate amount of pressure to apply when using our hands [5]. Touch in some cases may be a replacement for sight [5]. We get enjoyment from our sense of touch. Touch is essential to the communication of emotion. It gives us the ability to bond with others. Touch is so important between parent and child that a lack of touching can lead to serious developmental and emotional issues [6, 7, 8, 9, 10].
Our team set out to leverage this growing paradigm and take advantage of the large canvas that touch screens afford. Additionally, we wanted to consider touch in a multi-user context, which is not easily attained with the aforementioned smaller individual oriented devices. We also hypothesized that by leveraging existing autism therapies, we would be more equipped to design and build an interactive experience that would be aiding for this particular audience. This led our group in defining a set of goals that would enable us to develop a collaborative multi-user experience to support children with autism.

2.1 Why teach with touch

With touch screen technology becoming readily available in home computer systems, we ask the question of how to best utilize the power of 'touch' in the application of cooperative learning to meet the needs of autistic children and their caregivers. With touch, we can create a rich and meaningful experience that improves the lives of those with autism and those close to them. Touch allows learners who may have difficulty making the connection between the mouse and cursor to participate in a computer-based activity by directly interacting with learning objects on screen. Participants make direct connections between their input with the program and the resultant effect. Because repetitive and restrictive movements are sometimes difficult for autistic children, direct interaction through touch helps them practice basic motor skills and improve fine motor and perceptual skills.
Autistic children are drawn to technology [11]; it makes them feel safe because it is predictable. However, technology can be isolating for these children because it enables them to escape social situations, exacerbating traits that cause them to struggle in life. By requiring collaboration, we believe our application may lessen the anxiety resulting from learning skills that are very difficult. It allows the child to practice social and communication skills while using a tool that provides comfort and safety, in this case the HP TouchSmart computer (25 inch).

3 PROCESS

Our academic year is structured into three–10 week modules. This enabled us to plan on concrete outcomes at the end of each 10 week sequence. We structured our activities across three key phases; 1) problem definition and ideation, 2) design, prototyping, and usability testing, and 3) enhancements and development. We had regular weekly meetings with required deliverables each week. Each week consisted of project discussion, research updates, critiques, and action items.

3.1 Problem seeking and definition

As with many design initiatives, we began with an exercise in problem seeking. Problem seeking is an important phase in the development of interactive experiences. Too many times, designers jump into projects of this sort with poorly formulated requirements and misunderstood goals. Because we were committed to using a specific piece of hardware, in this case the HP TouchSmart computer, it was important for our team to first understand the inherent qualities the device would offer. Through our research, we determined that it would be optimal for a multi-user situation due to its large size screen (25 inches diagonally). It would enable the use of large-scale graphics, often suitable for young audiences. It would also support the convergence of various digital media such as audio, video, animation, text, and graphics to aid in dynamic communication.

The ability for one to directly engage and interface through touch was a strength of the device, however we also recognized that the input of touch with one's arm extended horizontally had a potential to cause fatigue. Thus, any system that required repetitive tasks and interaction would be counter-productive and exhaustive.

After determining the potential benefits of the hardware, we began to consider how to best apply the strengths of the device. Our department encourages a culture of using design for the greater good therefore our students tend to gravitate to projects that are altruistic. Through several brainstorming activities, discussions, and word clouds, the team believed that an application centred on teaching, learning, and dialogue through interaction would be a great benefit for a specific audience.

As stated earlier, autistic children have difficulty with communication and social interaction. They do however tend to gravitate to technology. We believed that we could utilize a touch screen application to encourage dialogue. So our hypothesis was that an interactive touch screen application that facilitated dialogue with a caregiver would enable them to practice communication skills in a context that is comfortable and engaging.

3.2 Roles

Now that we had agreed upon a common set of goals, each student was assigned a role. These team roles are important in that they enable the design team to have clear and purposeful discussion with an understanding of how each team member was to contribute to the project. We organized our efforts around sound, architecture, design, development, interaction models, and technology. Having this understanding at the beginning of the project help established how the students were to collaborate and the risk of team conflict was reduced [12].

3.3 Design

The team followed a similar user centred process seen in the design of web sites [13]. The unique component in our case however is the actuation of controls via touch. The utilization of the "awareness, understanding, action" model [13] was appropriately adopted for use in our context. Maintaining a sense of 'awareness' kept the team focused on considering our stakeholders at all phases of our design activity. It also encouraged the team to be mindful of any technological developments, user patterns, or system behaviours that would have an effect on our deliverables. The sense of 'understanding' was key in that it kept the team focused on delivering a user experience that would satisfy a desired and functional need, while leveraging the collective expertise of our team and collaborative partners. The 'action' phase guided the team in translating all of their ideas and research findings into a tangible, meaningful result. This process runs cyclical for the duration of our activities.

The team went through the typical iterative process of conceptualization, use case development, wireframes, visual style, and eventually user testing. Through several iterations, we consulted with autism advocates and caregivers who provided feedback on the usefulness of our proposed functionality and the visual language most likely to resonant with autistic children (Figures 1 and 2).

Figure 1. Students developed several iterations to the interface and task flow.

Figure 2. Autism SMEs provided feedback on elements most likely to resonant with autistic children

We eventually were led to developing scenarios based on the Centres for Disease Control and Prevention's 5-year-old developmental marker. This gave us structure around the type of content that would be most appropriate for the system. As the content developed with the assistance of subject matter experts from Autism Speaks, a non-profit organization dedicated to supporting research and increasing the awareness of autism spectrum disorders, we developed what we believe was a novel approach to autistic therapy. We proposed an interaction model that would facilitate the caregiver's engagement with the child. The application was modelled using a game like scenario using simple stories. These stories were created through a series of three questions and three transitions followed by an animation that tied everything together. The stories are set up to help the child learn to associate images with words, and how these images relate to one another. The caregiver prompts what story is initiated through the interaction of one of the visual icons (controls) as seen in Figure 3. The child is presented with four possible visual solutions and touches one of the image icons to continue the story as seen in Figure 4. The caregiver then has discussion with the child around the choices they make. The interaction model or dialogue that is created is triangular in nature. The application in a sense mediates a conversation between the caregiver and child and because the system responses are dynamically generated based on one's choice, the learning opportunities are rich and meaningful.

Figure 3. The caregiver initiates the story by interacting with one of the visual icons.

Figure 4. The child touches one of the four image icons to continue the story.

3.4 User testing

Once the initial prototype was complete, we moved into a user-testing phase. We believed this phase of the project's development was a critical step in validating the prototype. It is also a key component in a user centred design process. According the Usability expert Jakob Nielsen [14], *"Usability has assumed a much greater importance in the development of interactive experiences"*. We arranged a

series of empirical usability reviews with an area secondary school. We placed our usability learning objectives on the attributes of the system, which included graphics, sound, task flow and narrative structure. We wanted to understand how these elements facilitated a dialogue between caregiver and child. We also wanted to examine 'ease of use' and determine ways of improving the overall experience.

The results of the test were very positive. The usability characteristics of the system were well received. However, different children responded in different ways to audio stimuli. Some children responded negatively to sounds with certain affectations, whether designed to be negative or positive. Other children hyper focused on graphics that were solely placed in the application for aesthetic purposes and did not directly relate to the story. The result was to enhance the system with a library of sounds that the child could select and graphics that were reduced to the bare essentials. The visual feedback of controls was also reduced as to not distract the child from the lesson immediately at hand.

4 COLLABORATION WITH COMPUTER SCIENCE

We knew at the outset of this project that collaboration would be necessary to manage a project of this complexity. Once we established our respective roles and defined our agreed upon objectives, the collaboration within our design team went relatively smoothly. We did however realize that many functional project deliverables, whether it for the industrial, visual, or interactive media designer, will have a dependency upon another discipline. In this case, expertise in Computer Science was vital. We did not want to 'pass the project off' as that process was deemed subversive to our learning objectives. A collaborative activity between our design team and Computer Science Engineers would satisfy our desire to deliver a robust, functional solution while providing a platform to engage students from our institution's Department of Computer Science and Engineering (CSE).

Through a relationship with one of the CSE faculty members, a group of our design students enrolled in a CSE capstone course. Utilizing our proposed application as a case study, the CSE students embarked on a rigorous investigation for a programming solution. Students from Design worked with them in a consulting capacity. Ironically, the CSE students applied a similar workflow to that of the design students. They went through a definition phase, a UI development phase, and iterative development phase (using an agile software development methodology), and finally functional testing. During each phase of the development, students from the design team advised their colleagues on how the application could be improved. Through open conversation, the two student groups were able to determine the right balance of design ideals and development capabilities.

Another positive outcome from this phase of our project was that the design students were able to observe how their CSE counterparts went about approaching their deliverables. As a result, they were able to report on the application's development progress to the design team, clarify domain specific jargon, and eventually propose an ideal method for subsequent collaborations.

The result of our process and activates was a fully functional interactive application. The project was conceived by the students and in the end, delivered by them. This again gave the students a strong sense of fulfilment as well as an intimate understanding of the requirements and collaborative spirit needed in delivering a project to this scale.

5 BENEFITS AND CONCLUSION

Upon asking the students to reflect on their experience, several different benefits were revealed. Each student expressed a deeper understanding of the usefulness of a multi-disciplinary approach to building interactive learning applications. They believed they acquired a richer understanding of how to plan, design and execute interactive experiences through an immersive year long learning activity. The process was understood at a much more holistic level and the students determined in this situation, how to best apply the input of touch to improve one's user experience. In addition, they realized that the consideration of audience and the context of use for touch screen interactions must be carefully considered.

This long-term project experience also allowed the students to interact with subject matter experts in other disciplines. They were able to directly engage caregivers, autism researchers, advocates, instructors, software engineers and users. A bi-product of this engagement was that our students were required to hone their ideas and present them in a form that all stakeholders would understand. This communication became a design exercise within itself.

The cohort also had an opportunity to validate their concepts through user testing. The test involved observing a caregiver utilizing the application with an autistic child. By doing so, the students were provided insight that eventually lead to design changes and enhancements. Because of their involvement from concept to completion, they realized they had delivered a turnkey solution. They universally agreed that this would not have been possible if the experience was wedged into the time constraints of a quarter or semester.

One of the unique characteristics of the experience was that students themselves became project managers. They had to locate resources, manage time, determine roles and responsibilities, develop a usability test plan, manage testing logistics, and organize their work to delegate to a software development team. Students generally don't get these all inclusive experiences or opportunities, and all students believed they are more knowledgeable about the process and are better equipped for this type of work in a professional environment. And because they were the one's that defined the problem from the outset, they were strongly vested in working toward a successful outcome. Furthermore, the energy and cooperation of our collaborative learning environment facilitated reliance upon one another to achieve an agreed-upon goal. The experience instilled diligence, responsibility, and teamwork.

The experience also pushed us to answer the question, "how to best use touch screen technology". This directed the group to really applying the concept of user centred design. The project eventually became one of outreach and in doing so, was able to help children with autism and their caregivers concretely rather than speculatively.

REFERENCES

[1] Robles-de-la-Torre, Gabriel. The Importance of the Sense of Touch in Virtual and Real Environments. *Special issue on Haptic User Interfaces for Multimedia Systems*, IEEE Multimedia 13(3), 24-30.

[2] Hayward, Vincent, et al. Haptic Interfaces and Devices. *Sensor Review*. Volume 24, No. 1, 2004. pp 16-29. <http://www.roblesdelatorre.com/gabriel/VH-OA-MC-DG-GR-04.pdf>

[3] "HowStuffWorks Videos 'Understanding: Sense of Touch'" *Howstuffworks "Video Channel"* Web. Accessed February 2010. <http://videos.howstuffworks.com/tlc/29845-understanding-sense-of-touch-video.htm>.

[4] "Bonding With Your Baby." *KidsHealth - the Web's Most Visited Site about Children's Health.* Web. Accessed February 2010. <http://kidshealth.org/parent/pregnancy_newborn/communicating/bonding.html>.

[5] "The Importance of Touch in Parent-Infant Bonding." *Welcome to TSBVI!* Web. Accessed February 2010. <http://www.tsbvi.edu/Outreach/seehear/fall00/infantbonding.htm>.

[6] *Care Through Touch Institute*. Web. Accessed January 2010. <http://www.carethroughtouch.org>.

[7] "Answers.com - Why Is Touch the Most Important Sense." *WikiAnswers - The Q&A Wiki*. Web. Accessed December 2009. <http://wiki.answers.com/Q/Why_is_touch_the_most_important_sense>

[8] "The Healing Power of Touch: the Simple Act of Touching Frequently Reduces Everyday Anxiety and Tension - American Fitness Articles | Find Articles at CBS MoneyWatch.com." *Find Articles at BNET | News Articles, Magazine Back Issues & Reference Articles on All Topics*. Web. Accessed December 2009. <http://findarticles.com/p/articles/mi_m0675/is_n6_v9/ai_11489808/>.

[9] "Human Touch Is Necessary." *Anger Management Techniques, Information On Eating Disorders, Anorexia, Psychology Articles and More on Mind Publications*. Web. Accessed January 2010. <http://www.mindpub.com/art173.htm>.

[10] Lacey Jennifer. "Baby Bonding: The Power of Touch | Articles | Babies Today." *Babies Today | Baby Articles, Baby Care Advice, Baby Gifts, Baby Toys, Toddler and Newborn Info*. Web. Accessed December 2009. <http://www.babiestoday.com/articles/guiding-babys-development/baby-bonding-the-power-of-touch-1783/>.

[11] Goldsmith T.R. and LeBlanc L. Use of Technology in Interventions for Children with Autism. *Journal of Early and Intensive Behavior Intervention*. Volume 1, Issue Number 2, 2004, 166

[12] "Designer's Role in a Design Team." Design Collaboration Northumbria University. Video Accessed January 2011 <http://www.designcollaboration.org/resources/roles/designer-roles.php>

[13] Cato John. *User-centered Web Design*, 2001 (Addison-Wesley, Harlow, England).

[14] Nielsen Jakob. *Designing Web Usability*, 2000 (New Riders, Indianapolis, IN)