Designing Touchscreen Interfaces that Don’t Interfere with Learning

Lisa Anthony
Dept of CISE
University of Florida
Gainesville, FL 32611 USA
lanthony@cise.ufl.edu

Quincy Brown
Bowie State University
14000 Jericho Park Road
Bowie, MD 20715
qbrown@bowiestate.edu

Abstract
Speaking broadly, interfaces for educational technology can either be natural and easy for learners to use, or they can be awkward and difficult for learners to use. In the latter case, the learner’s focus inevitably shifts to learning the interface rather than the material at hand. We present our work on designing and developing more effective educational interfaces, specifically for touchscreen devices, by building on user-centered design practices. The primary context of our work is mobile touch and gesture interaction for children and educational technology.

Author Keywords
Child-computer interaction; interaction design; user-centered design; touch and gesture interaction; mobile; touchscreens; educational technology.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

Introduction
In general, interfaces for educational technology can either be streamlined, natural, and easy for learners to use, or they can be cumbersome, awkward, and difficult for learners to use. In the latter case, the learner’s focus inevitably shifts to learning the interface rather than the material at hand. Interfaces that have not been designed with the user in mind are less effective [13]. The field of human-computer interaction

was founded on the insight that, if we design the way people interact with software based on knowledge of psychology and cognition, the software is more effective [13]. We apply this philosophy and approach to designing software for children, specifically educational interfaces for touchscreen devices. We present our work on designing and developing more effective educational interfaces for touchscreen devices, by building on user-centered design practices. The primary context of our work is mobile touch and gesture interaction for children. We investigate how children use touch and gesture input to ensure that touchscreen interfaces for educational software are built with children's needs in mind.

The MTAGIC Project

We have been pursuing this research in an NSF-funded project we call MTAGIC ("Mobile Touch and Gesture Interaction for Children", the *t* is silent!). Over the past three years we have conducted several empirical studies analyzing how the touchscreen input patterns of children, ranging in age from 7 to 17 years old, differ from that of adults, 18 and over [1-4,6-9]. Cumulatively over these studies we have found many differences in how kids interact with touchscreens that significantly impact how successfully applications are able to respond to children's input.

Children miss targets more frequently than adults [2,4,7]. This behavior difference makes it difficult for applications to infer which target the child meant to touch, leading either to unresponsiveness or incorrect responses by the application.

Children have more difficulty touching smaller targets than do adults [2,4]. This behavior difference means that applications that use very small onscreen targets (e.g., ¼" or smaller) may not be able to appropriately identify the child's intended target, as their touches will be outside the bounds of the available targets.

Children make gestures with more strokes than adults, on average [7]. This behavior difference makes it difficult for current gesture recognition algorithms, designed to recognize adult gestures, to recognize children's gestures with acceptable accuracy [2,3,4].

The younger the child, the less consistent they are in how they make gestures [3,4]. This behavior difference is evident in the strong positive correlations we have found between age and recognition accuracy in our work with children as young as seven years old [3,4]. Current gesture recognition algorithms' performance is predictably poorer the younger the child is.

These are a few of our main findings with respect to touch and gesture input behavior differences between children and adults. All of them contribute to a decreased ability by the application to understand what the child's intended action was, leading to unresponsiveness or even incorrect responses. In a learning application, such mistakes can lead to distraction and frustration, preventing the child from getting the most out of the learning experience [1,4,5].

Designing Better Learning Interfaces

Knowing some of the challenges children may experience in trying to use touchscreen interfaces for learning software enables the design of smarter interfaces that work around these challenges to allow the children to focus on learning the content rather than the interface. We use user-centered design methods such as participatory design and co-design to work with children (e.g., [11,12,14]). For example, we present simple prototypes of apps we build to demonstrate the concept of intelligent software that can recognize what one means. Then, we engage children in participatory design activities to decide what the application should do when it doesn't understand what target they touched or what gesture they drew. The goal of these design activities is to identify ways in which the interface can be designed so it doesn't interfere with learning. For example, perhaps the software does not expose to the child that it is not sure what the child wrote; instead it can wait for more input to help increase its confidence in its interpretation.

MTAGIC Math Scenario

We now describe a hypothetical scenario of a learning interface that has been designed with these goals in mind. Imagine a scenario in which a student, Sam, 8 years old, uses MTAGIC Math, an intelligent tutoring system that runs on a tablet. In the MTAGIC Math app, onscreen interactive widgets such as buttons, menus, and sliders use more tolerant models of "acceptable touch locations." Sam is using a number line interface to practice subtraction. When Sam touches near a mark on the line, an intelligent layer determines the probability of the touch being directed at nearby marks (all defined as interactive widgets). For touches just slightly outside the visual boundaries of a mark on the line, MTAGIC Math is able to recognize which line mark Sam intended to touch, determined probabilistically based on empirically-derived distance thresholds. Similar approaches have been used for onscreen virtual keyboards and found to be successful [10].

MTAGIC Math also recognizes simple gestures to let Sam practice the math skills currently being taught in class. For example, MTAGIC Math can support recognition of numbers for multiplication and division practice, fraction practice, number line practice, and more. MTAGIC Math uses recognition approaches built from the corpus of age-specific gesture samples we have collected in our foundational studies. These recognizers are tailored to the kinds of inconsistent gestures generated by elementary and middle school students like Sam. Even so, incorrect recognitions will still occur sometimes. A primary design goal of MTAGIC Math is to ensure that such recognition inaccuracies won't interfere with Sam's learning. MTAGIC Math avoids distracting the students by focusing any interventions in which the system cannot make a confident determination about what Sam's touch or gesture input means on learning-oriented prompts. Prior work has successfully used such interactive paradigms for desktop intelligent tutors [5].

Learning environments like the hypothetical MTAGIC Math app in this scenario make use of HCI interface and interaction design methods and techniques. The use of these techniques for intelligent touchscreen interfaces allow students to focus on learning, rather than on interacting or correcting the interface.

Acknowledgements

The authors thank the students who have contributed to the MTAGIC project over the years, including: Robin Brewer, Thaddeus Brown, Brittany Craig, Juthika Das, Phillip Hall, Akshay Holla, Germaine Irwin, Shreya Mohan, Jaye Nias, Monique Ogburn, Chiamaka Okorohoa, Sagar Parmar, Luis Queral, Danielle Sikich, Berthel Tate, Julia Woodward, and Qingchuan "Bruce"

Zhao. This work is partially supported by National Science Foundation Grant Awards #IIS-1218395 / IIS-1433228 and IIS-1218664. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect these agencies' views.

References

1. Anthony, L. and Brown, Q. 2013. Learning from HCI: Understanding Children's Input Behaviors on Mobile Touchscreen Devices. Paper for *CSCL 2013 Workshop on Human-Computer Interaction and the Learning Sciences*, Madison, WI, 15 June 2013.
2. Anthony, L., Brown, Q., Nias, J., Tate, B., and Mohan, S. 2012. Interaction and Recognition Challenges in Interpreting Children's Touch and Gesture Input on Mobile Devices. In *Proc. ITS 2012*. ACM, New York, NY, USA, 225-234.
3. Anthony, L., Brown, Q., Nias, J., and Tate, B. 2013. Examining the Need for Visual Feedback in Gesture Interaction with Mobile Touchscreen Devices for Kids. In *Proc. IDC 2013*. ACM, New York, NY, USA, 157-164.
4. Anthony, L., Brown, Q., Tate, B., Nias, J., Brewer, R., and Irwin, G. 2014. Designing Smarter Touch-Based Interfaces for Educational Contexts. *Personal and Ubiquitous Computing* 18, 6 (2014), 1471-1483.
5. Anthony, L., Yang, J., and Koedinger, K.R. 2012. A Paradigm for a Handwriting-Based Intelligent Tutor. *International Journal of Human-Computer Studies* 70, 11 (2012), 866-887.
6. Brewer, R., Anthony, L., Brown, Q., Irwin, G., Nias, J., and Tate, B. 2013. Using Gamification to Motivate Children to Complete Empirical Studies in Lab Environments. In *Proc. IDC 2013*. ACM, New York, NY, USA, 388-391.
7. Brown, Q. and Anthony, L. 2012. Toward Comparing the Touchscreen Interaction Patterns of Kids and Adults. Paper for *CHI 2012 Workshop on Educational Interfaces, Software, and Technology*, Austin, TX, 05-06 May 2012.
8. Brown, Q., Anthony, L., Brewer, R., Irwin, G., Nias, J., and Tate, B. 2013. Challenges of Replicating Empirical Studies with Children in HCI. In *Proc. RepliCHI 2013 (CHI 2013 workshop)*, Paris, France, 27-28 Apr 2013, p.54-58.
9. Brown, Q., Anthony, L., Nias, J., Tate, B., Brewer, R., and Irwin, G. 2013. Towards Designing Adaptive Touch-Based Interfaces. Paper for *CHI 2013 Workshop on Mobile Accessibility*, Paris, France, 28 Apr 2013, 4pp.
10. Findlater, L., & Wobbrock, J. O. (2012). Personalized input: improving ten-finger touchscreen typing through automatic adaptation. In *Proc. CHI 2012*. ACM, New York, NY, USA, 815-824.
11. Druin, A. 1999. Cooperative inquiry: developing new technologies for children with children. In *Proc. CHI 1999*. ACM, New York, NY, USA, 592-599.
12. Druin, A., Bederson, B.B., Hourcade, J.P., Sherman, L., Revelle, G., Platner, M., and Weng, S. 2001. Designing a digital library for young children. In *Proc. JCDL 2001*. ACM, New York, NY, USA, 398-405.
13. Grudin, J. 2012. A moving target: the evolution of human-computer interaction. In *The Human-Computer Interaction Handbook* (3rd. ed.), Julie Jacko (Ed.). CRC Press, Boca Raton, FL, USA, xxvii-lxi.
14. Scaife, M., Rogers, Y., Aldrich, F., and Davies, M. 1997. Designing for or designing with? Informant design for interactive learning environments. In *Proc. CHI 1997*. ACM, New York, NY, USA, 343-350.