Learning via Gaming: An Immersive Environment for Teaching Kids Handwriting

The University of Michigan-Dearborn
Henry W. Patton
Center for Engineering Education and Practice

Center for Engineering Education and Practice
Technical Project Report

Learning via Gaming: An Immersive Environment for Teaching Kids Handwriting

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Synopsis

Immersive learning via animation, virtual experiments, and simulations is an attractive concept. As the complexity of educational content increases, its delivery methods and pedagogy must improve as well. While the efficacy of immersive environments for education and training is well established, their use with elementary and middle schools students is negligible. Hardware costs and long development times are two major factors impeding development of such environments for younger students. Computing technology, specifically tools for human machine interface development, has come a long way in the past few years. The authors are making use of this emerging technology to develop an immersive gaming environment for teaching handwriting to elementary school children using a tablet PC delivery system.

1. Background

There has been a fair amount of research on user interface design for children [1, 2], error rates in text entry user interfaces [3], interactive teaching environments using Tablet PC's [4, 5] and using games as tools to promote learning in and out of the classroom [6, 7]. There has been very little research done on combining all of these elements into a tool suitable for teaching children how to write.

A tablet PC comes equipped with a touch screen that is designed to work with a pen input device known as a stylus. Students can use the stylus to perform all user functions associated with an ordinary mouse, but more importantly, the Tablet PC allows students to use the stylus to write directly on the PC display screen. Interacting directly with the PC display screen provides users with an environment that is very easy to use. Studies suggest that young children may have problems using the standard QWERTY keyboard as a writing composition tool. There is some evidence that suggests children may write more easily using a Tablet PC stylus than by typing on a PC keyboard [3].

Some teachers feel that computer games can motivate students to maintain their attention on the goals of particular learning activities [8]. Video games can teach hand-eye coordination, spatial relationships, and encourage exploratory experiences. Immersion in simulated environments has increased learning speed and retention for some tasks. Video games can engage players for two or more hours, yet these same students may lose interest in classroom activities after only fifteen minutes [9].

Many people feel that games may enhance the classroom environment by allowing the teacher to play a less dominate role and not being forced to serve as the sole judge of student performance [8]. This allows teachers to assume a coaching role and guide students during learning tasks. Games can be a powerful and pervasive way to take learning outside the classroom [6].

When playing a computer game, children may notice the multimedia content in the game, have fun interacting with game elements, and observe how easy some things are to learn [10]. There are several interface design issues that need to be addressed when creating game environments for children. Some of these include: creating consistent and predictable user dialogs, offering informative feedback, providing simple error handling, and reducing the user's short term memory load [1]. Dealing with non-readers requires the use of audio and unambiguous video feedback and user guidance.

Children learn to write at different rates, in different ways, and with different capacities [11]. Intelligent tutoring systems go beyond the limitations of traditional computer-based training systems [8]. Intelligent tutoring systems use information on a student's current and past performance to deliver customized content in a style best suited to the student's current instructional needs [12, 13].

2. Objectives

- Establish a strong game design and development educational curriculum at the University of Michigan-Dearborn
- Develop a strong research program in the field of immersive learning, providing a rich collaborative platform for experts in game development, multimedia computing, pattern recognition, and human computer interaction.
- Develop a strong relationship with elementary schools for assessing the effectiveness of our software products and writing collaborative funding proposals for enhancing education via innovative methods.

3. Approach

The goal of this project is to create an immersive gaming environment using a Tablet PC that teaches children to write using the D'Nealian handwriting system [11]. While interacting with the game, students are taught to write new letters or words as a means of opening reactive game elements. Students gain access to new game features by writing required letters using the methods taught. An intelligent tutoring system provides feedback on the children's work, telling them what they did right or wrong, and how to correct their errors if any. As players progress through the letter worlds they are given access to entertaining mini-games to reward their mastering

letter world objectives. Students earn game tokens by writing letters correctly. Figure 1 shows a screenshot from the immersive game environment.

FIGURE 1
STUDENT SCREEN LAYOUT.

The system design contains three key modules: (1) an interactive gaming environment where kids play in a game environment to unlock mini-games, (2) a student writing evaluation and feedback module, and (3) a teacher evaluation and feedback module. The system prototype created during the second years of the project includes working prototypes of the gaming environment and student feedback module. The current prototype is programmed using Microsoft C#, WPF, and the XNA library to ensure easy installation on the player's home computer. The development of the teacher feedback module is planned for the third year of the project.

The story begins with Ollie the Octopus. Ollie is the chief engineer for Pickle's Printing Playground. Pickles Printing Playground or PPP for short specializes in creating words, using individual robot letters, for people all over the world. His job at PPP is to answer incoming phone calls, place the word orders, and send them out. One day, while busy at work, one of Ollie's tentacles knocks over a cup of coffee that was sitting on the control panel. The coffee spills into the panel and causes the machine to malfunction. When this happens, the robot letters that were controlled by the same machine escape into the playground behind the factory. Pickles job is to enter the playground, find all of the individual robot letters, capture them by writing their grapheme correctly and return them to the factory.

When Pickle (the player's avatar) enters the game world, Pickle sees a world a map showing the order in which the letters are to be trapped. This order matches Thurber's sequence for teaching handwriting [Thurber]. The player unlocks the path to each new letter by trapping the next letters in the sequence. For example Pickle cannot go past the "a" world arch unless letter "a" has been captured.

Each letter world provides a unique experience to the player. Each letter world Pickle enters is filled with objects of that begin with that letter (i.e. the "g" world features a giraffe as the main character, a globe, a gopher, gears, a ghost, and a gate to exit to the next letter world). The object's name is presented on the screen and spoken each time the object is animated by Pickle's touch.

The first time a player writes the letter he or she is allowed to trace a sample letter. The second and third time a player writes a letter, he or she copies the letter without the tracing guide. Each time one of these tasks is

completed correctly, the player is allowed to play one of the active mini-games. The mini-games serve to motivate students to complete levels and to provide practice opportunities for writing letters.

Figure 2 shows the architecture of the intelligent tutoring system. Our system incorporates a series of remediation rules that have been developed by both our research team and Dr. Donald Thurber, the creator of the D'Nealian handwriting system [11]. These rules guide the users through the game and help them develop their handwriting skills. Some of these rules deal with generic problems such as letter size, shapes, and number of strokes used to write the letter. Some rules are specific to individual letters. The letter "a" should be written with three distinct strokes (around-down, up, and monkey tail). The letter "g" needs to end with a fish hook that extends below the line. The letter "d" needs to reach to the top of the first solid line on the writing surface.

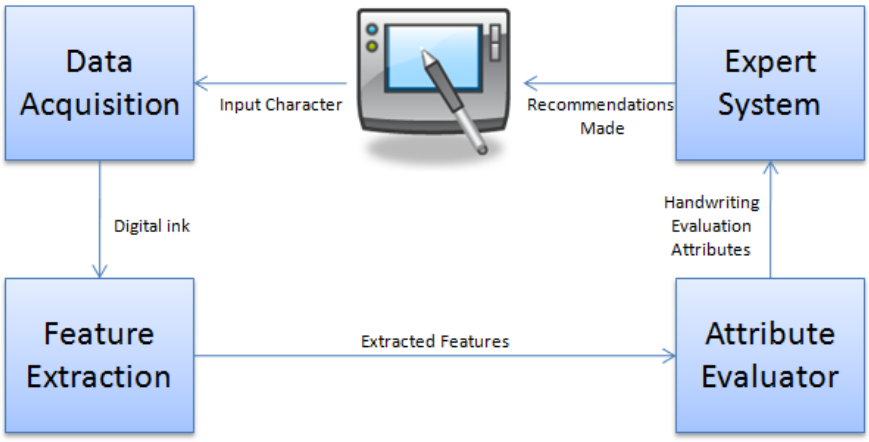

FIGURE 2
INTELLIGENT TUTORING SYSTEM ARCHITECTURE.

The remediation system allows the user to practice writing a particular letter stroke until he or she has done it correctly. Audio output and narrated animations are used to provide instructions and feedback to non-reading students. Part of the feedback given is one of a series of checkmarks. A green checkmark means the letter is good, a yellow checkmark means the letter is OK but not perfect and red checkmark means that the letter was not written correctly.

4. Results

The project team devised a neural network capable of scoring student handwriting attributes using D'Nealian teaching method during the first year of the project. During the second year of the project the investigators devised a rule-based approach to guide the student remediation process. The investigators created a handwritten character recognition algorithm that out performs Microsoft Ink for the D'Nealian font.

The project team created two working prototypes of the game environment. The first prototype was built using C# and Flash [Maxim]. We had a great deal of trouble passing information gathered from the tablet PC ink system to flash and vice versa. In addition, using Flash slowed down the performance of the entire system. The second prototype was created using C#, XNA, and WPF. This proved to be a better platform for this particular application. It was relatively easy to interact with the ink system from C#. Using C# and WPF made it very easy to transfer control in and out of the mini-games from the various letter worlds.

Sixteen senior and graduate level students, studying game design at the authors' institution, evaluated the first prototype through play testing. These students used a five-point scale (1=poor, 5=excellent) to rate the prototype. Their average rating of the usability of the software is 4.9, the average reliability rating of the software is 4.9, the average entertainment value of the software is 4.5, and the quality of the game premise 4.7 [14].

Six elementary school teachers who teach writing skills to their students evaluated the second software prototype through active use of its intelligent tutoring capabilities. These teachers used a five-point scale (1=poor,

5=excellent) to rate the prototype. Their average rating of the ease of navigation for the software is 4.2, the average game playability rating of the software is 4.6, and the rating of the writing feedback module is 4.5.

5. Conclusions

The project team feels that they have established the feasibility of using the Tablet PC as a delivery system for the game environment and intelligent tutoring system. Knowledge acquisition has proceeded more slowly than planned. The authors are working with Dr. Thurber to create a more robust knowledge base for the intelligent tutoring system. The authors plan to begin testing the system with young children during the fall of 2008. Creation of art assets is a time consuming process. Without the use of students from nearby art colleges to enhance the multimedia game library this project would not have progressed to its current state. The teacher feedbaqck module will be implemented in the next software prototype.

6. Impact

Educational:

Nicholas Martineau (Graduate Student Research Assistant) has been intimately involved in the three external grants we submitted to support our work. He contributed substantially to a paper that was be presented at the 2007 IEEE Frontiers in Education Conference and a second paper that will be presented at the Meaningful Play Conference at Michigan State University in October 2008.

Brian Schroeder created the user interface design and presentation framework used in the final prototype as part of his work in CIS 591. Students taking CIS 4951, CIS 4961, CIS 4952, CIS 4962 (Senior Design) created 6 mini-games that were integrated into the final game prototype entitled "Pickle's Printing Playground" (Matthew Sable, Marcus Gilbert).

Students taking CIS 487 and CIS 587 participated in the initial play testing of the evolving prototype of the immersive game environment during the Fall 2006 semester. Two art students (David Marquez and Katherine Maxim) created the art work used in the various prototypes of the immersive game environment.

Industrial:

This project has the potential to open new opportunities in the educational gaming industry that is beginning to emerge in the state of Michigan. Several of recent CIS graduates have found employment in large California game studios. At least one Michigan game development company has found it impossible to identify qualified candidates for open game programming positions.

In part, this interaction has attracted the interest of Brad Jensen from Detroit City Connect to inquire about having CIS Senior Design students work on a serious game based on the life of a homeless person in Detroit. This game was completed in April 2008 as a CIS senior design project.

This project also attracted the interest of Ford Foundation chair Michael Schneider who encouraged us to apply for a challenge grant focused on using Second Life (an immersive virtual 3D environment) to support the creation of sustainable problem solving communities. Our proposal was funded for the 2008-2009 academic year.

7. Acknowledgements

The Henry Patton Center for Engineering Education and Practice provided the majority of the funding for this project. The Verizon Foundation provided funding for creation of the project multimedia components. Additional funding was contributed by Mandala Sciences. The team is deeply appreciative of the time and expertise contributed to this project by Dr. Don Thurber.

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