

Animated Versus Static User Interfaces: A Study of Mathsigner™

Scott Dyer, and Nicoletta Adamo-Villani

Abstract—In this paper we report a study aimed at determining the effects of animation on usability and appeal of educational software user interfaces. Specifically, the study compares 3 interfaces developed for the Mathsigner™ program: a static interface, an interface with highlighting/sound feedback, and an interface that incorporates five Disney animation principles. The main objectives of the comparative study were to: (1) determine which interface is the most effective for the target users of Mathsigner™ (e.g., children ages 5-11), and (2) identify any Gender and Age differences in using the three interfaces. To accomplish these goals we have designed an experiment consisting of a cognitive walkthrough and a survey with rating questions. Sixteen children ages 7-11 participated in the study, ten males and six females. Results showed no significant interface effect on user task performance (e.g., task completion time and number of errors); however, interface differences were seen in rating of appeal, with the animated interface rated more 'likeable' than the other two. Task performance and rating of appeal were not affected significantly by Gender or Age of the subjects.

Keywords—Animation, Animated interfaces, Educational Software, Human Computer Interaction, Multimedia.

I. INTRODUCTION

A few research studies have reported the cognitive and affective benefits of incorporating the principles of animation in software user interfaces. In this paper we add to the relatively small body of literature in this area of research by presenting a study aimed at investigating usability and appeal differences of three versions of the Mathsigner™ interface (two static and one animated).

Mathsigner™ [1] is a 3D animation-based program for teaching math concepts and related American Sign Language (ASL) signs to deaf and hearing children in grades K-3. The software is currently under development and undergoing a series of formative evaluations. The results of this study will be used to inform the final decision on which interface design to adopt.

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The paper is organized as follows: In section II we (a) discuss the 12 principles of animation, (b) present a summary of previous work on animated interfaces, and (c) describe the Mathsigner™ application and its evaluation methodology. In section III we present the user study, and in section IV we report the findings. Discussion of results and conclusive remarks are included in section V.

II. BACKGROUND

A. The 12 Principles of Animation

“Between the 1920’s and the late 1930’s animation grew from a novelty to an art form at the Walt Disney Studio” [2]. Thanks to Disney, the growth and development of traditional animation helped produce 12 fundamental principles [3] that are still used and applied today. These principles include: Squash and Stretch; Timing; Anticipation; Staging; Follow Through and Overlapping Action; Straight Ahead Action and Pose-To-Pose Action; Slow In and Out; Arcs; Exaggeration; Secondary Action; Appeal; Solid Drawing.

We have implemented 5 of these 12 principles in our animated interface: (1) *stretch and squash*- Techniques that define object rigidity and mass by manipulating or distorting its shape during an action; (2) *follow through and overlapping action*- Upon ending one action, establishing a relationship to the next action; (3) *slow-in slow-out*- The spacing of the in-between frames to achieve acceleration and deceleration at the beginning and ending of the action, respectively; (4) *Anticipation* - Preparing the audience for an action to come; and (5) *Arcs* -The curved path of action for movement.

The selection of these 5 principles was based partially on research by Chang and Ungar [4], and was motivated by the following considerations. Changes of shapes (e.g., stretch and squash) give objects solidity and provide users with selection feedback. Follow-through and anticipation make inter-connections between different interface states logical and clear, while slow-in-slow-outs provide smooth transitions between them. Motion that describes arcs is visually pleasing and can increase the overall appeal of the interface.

B. Previous Work on Animated User Interfaces

A few research studies report the benefits of implementing animation in software user interfaces [5-8]. The two main benefits highlighted by all the studies are (1) a reduced user’s cognitive load and (2) a higher level of appeal. Cognitive benefits result primarily from the fact that animation allows

for continuous transitions between different interface states, thus making the connection between the old state of the screen and the new state of the screen immediately clear. Because the effort to understand interface changes is transferred from the cognitive to the perceptual system, the user is able to focus more attention to the task at hand and, therefore, be more efficient with the software [9;4].

Thomas and Calder [10] describe how cartoon animation techniques can enhance direct manipulation human computer interfaces by giving manipulated objects a feeling of substance (e.g., through stretch and squash) and by providing cues that anticipate the result of a manipulation (e.g., through the principles of anticipation and staging).

Baudisch et al. [11] argue that while animated transitions in the interfaces may help a user track changes in interface states, they may also introduce "lag". In other words, users have to wait for the animation to end before they can proceed to the next task. To solve this problem they propose to replace traditional animated transitions, such as sliding actions, with an alternative form of animation: afterglow effects (called *Phosphor*). The main difference between Phosphor transitions and the traditional animated transitions is that, "...Animated transitions explain the transition *and then* continue the regular execution of the program; phosphor transitions do both *at the same time*" (p.170).

In regard to affective benefits, Chang and Ungar [4] suggest that by eliminating sudden, startling changes in contents of the screen, animation makes the interface less confusing and therefore the user's experience is more pleasant. In a study conducted by [10], participants rated an animated direct manipulation human computer interface more interesting than a static one primarily because of the look of the animated objects ('softer') and the clarity and smoothness of changes.

C. Mathsigner™

Mathsigner™ is a 3D animation ASL-based interactive software package which contains sets of activities, with implementation guidelines, designed to teach K-3 math concepts, ASL signs, and corresponding English terminology to deaf and hearing children, their parents, and teachers [1]. The prototype application contains two programs, one aimed at deaf and hearing children and the other aimed at hearing parents of deaf children. Each has two modes of operation - a learning mode and a practice/drill mode - characterized by different color schemes. The screen layout (shown in figures 3-5) consists of two frames: The frame on the left is used to select the grade (K-1, 2 or 3) or the type of activity; the frame on the right shows the 3D signer. The upper area on the left gives textual feedback as appropriate; the bottom area shows the navigational buttons. The frame on the right contains a white text box below the signer, to show the answer (in mathematical symbols) to the current problem. Below this, there is a camera icon and an arrow. The arrow (slider) is used to control the speed of signing; the camera button opens a menu to zoom in/out on the 3D signer, change the point of view and pan to the left or to the right within the 3D signer window. A demo of Mathsigner™ is available at <http://www2.tech.purdue.edu/cgt/i3/>

Mathsigner™ is being developed using an iterative, user-centered design approach which includes three forms of assessment: expert panel-based, formative, and summative. The expert panel-based and formative evaluations focus on the design features of the application, whereas the summative evaluation tests the efficacy of using the software for teaching K-3 math concepts to deaf and hearing children. The study reported in this paper is a user-centered formative evaluation aimed at improving the design of the software interface. The study includes a commonly used interface inspection method: cognitive walkthrough. A cognitive walkthrough is a technique for evaluating the design of a user interface, with special attention to how well the interface supports "exploratory learning," i.e., first-time use without formal training [12]. The evaluation is done by having a group of evaluators and/or target users go step-by-step through commonly used tasks.

III. DESCRIPTION OF THE STUDY

A. Materials

Interfaces

The three interfaces used in the experiment are simplified variations of the original Mathsigner™ interface and have been created for the purpose of this study using Adobe Flash [13]. Adobe Flash was chosen because of its ease of use and its many pre-built components that assist with rapid-prototyping.

Interface 1 (static): The static interface does not include any continuous transitions between interface states. There is no sound or visual feedback and the screens between activities flicker and pop-up suddenly.

Interface 2 (highlighting and sound feedback): This interface includes user feedback in the form of sound and highlighting. Specifically, it uses blue highlighting and 'click sounds' for the buttons and activities.

Interface 3 (Animated): The animated interface incorporates 5 of the 12 principles of animation defined by Thomas and Johnston [3]. In particular, the interface makes use of the principles of *Squash and Stretch*, *Anticipation*, *Slow-in and Slow out*, *Arcs*, and *Follow-through*. Buttons, arrows, and text fields *squash and stretch* with *follow-through* action each time the user clicks on them. Changes in interface states are implemented with continuous transitions between screens with the old screen sliding *slowly out* of view and the new one sliding *slowly in*. Objects (e.g., the 2D shapes) move in *arcs* when the user rolls the mouse cursor over them. The start of the signing animation is always *anticipated* by a slight bouncing movement of the 3D character. This *anticipation* is used to draw the user's attention to the signer's frame located on the right side of the screen. Fig. 1 illustrates the implementation of these 5 principles in the Mathsigner™ interface.

A demo of the three interfaces is available at:

<http://www2.tech.purdue.edu/cgt/i3/interfaces.html>

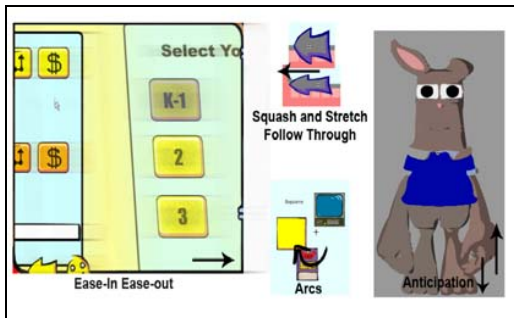


Fig. 1 Integration of 5 principles of animation in Mathsigner™ interface

B. Participants

16 children age 6-11 years; 10 males and 6 females

C. Procedure

The experiment included a pre-test, a cognitive walkthrough and a survey administered at the end of the hands-on session.

Pre-test: All participants were given a pre-test with questions related to experience with computers and video game familiarity. All questions and directions were read out loud to the subjects to ensure comprehension. Subjects rated the response to each question using a pictorial Likert scale with 4 smiling faces (See Fig. 2). The answers were recorded by the authors.



Fig. 2 The pictorial Likert Scale

Cognitive walk-through: Each interface was displayed on a Dell Precision M70 laptop with a 17" Flat Panel Monitor and a resolution of 1280x800 pixels. The computer was positioned on a desk and subjects sat at a distance of about 0.5 meters from the monitor. All participants performed the test individually and interacted with the interface using mouse and keyboard. Each subject was presented with one interface only and the interfaces were randomized among subjects. The order in which the participants performed the activities was the same for all interfaces and all subjects.

The participants were asked to perform a cognitive walkthrough which included three tasks: (1) count and display the number '467' using an iconic representation (Fig. 3); (2) type and display the solution to the math problem "5+5" (fig. 4); and (3) select the square shape group (Fig. 5).

Task (1) involved 12 actions and required the user to: navigate to the 'Learning to Count' module by mouse-clicking on the arrow buttons, select the correct number by mouse-clicking on the gems, mouse-click the 'Sign it' button

to display the number in text format, and navigate back to the intro screen.

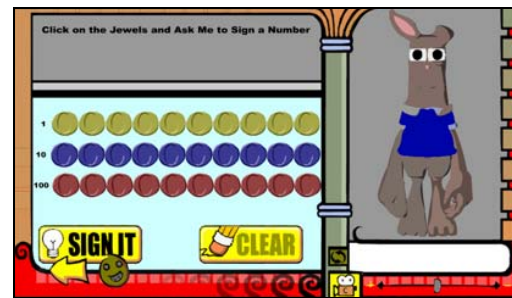


Fig. 3 Mathsigner™ counting activity (task 1)



Fig. 4 Mathsigner™ mathematics activity (task 2)



Fig. 5 Mathsigner™ shapes activity (task 3)

Task (2) involved 15 actions and required the user to: navigate to the 'Addition-Subtraction' module by mouse-clicking on the arrow buttons, use the keyboard to input the problem '5 + 5' in the appropriate text fields, mouse-click the "Sign-it" button to display the answer, and navigate back to the intro screen.

Task (3) involved 8 actions and required the user to: navigate to the 'Learning Shapes' module by mouse-clicking on the arrow buttons, identify the square shape group among three groups of shapes (triangles, squares, and circles) by placing the mouse cursor on it, and navigate back to the intro screen. A detailed list of all the actions for the 3 tasks can be found in the appendix.

The children's screen activities and task completion times were recorded using a screen capture program (e.g., Camtasia Studio 3 software). Each participant was given a maximum time of 10 minutes to complete all 3 tasks. For each activity, the authors recorded (in writing) completion/non-completion

of actions, number of mistakes per action, and completion of actions with help. A sample table used for collecting these data is included in the appendix; the table format is based on research by [12]. In addition, observation and think aloud protocol were used throughout the experiment in order to gain more insight on children's performance and preferences.

Survey: In order to measure the appeal of each interface we used a survey with 3 rating questions. We asked the children to rate how much they liked the buttons (question 1), how much they liked the arrows (question 2), and how much they enjoyed going from one screen to the other (question 3). Subjects rated the response to each question using a pictorial Likert scale with 4 smiling faces (See Fig. 2). The answers were recorded by the authors.

IV. RESULTS

User task performance is measured by *task completion time* and *number of errors* while performing a task.

A. Task Performance and Appeal by Interface

Results show that while there are differences in the mean task completion times of the 3 tasks using the 3 interfaces (all completion times are lower for the animated interface), these differences are not statistically significant using an alpha value of .05. The One Way ANOVA analysis yielded p-values of 0.581, 0.985, and 0.452 for tasks 1, 2 and 3, respectively. Fig. 6 illustrates the means completion times for each task using the 3 interfaces.

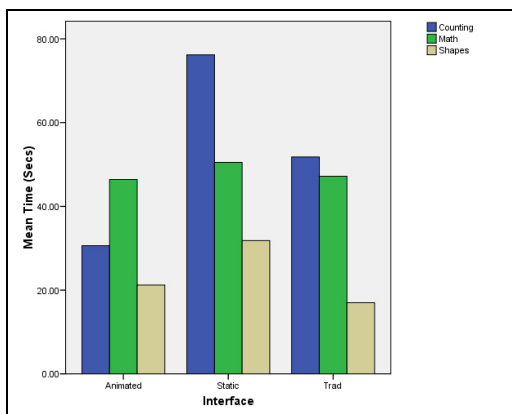


Fig. 6 Means Comparison of Task Completion Times

In regard to number of errors, results show that while there are differences in the mean number of errors made while performing the 3 tasks using the 3 interfaces, these differences are not statistically significant using an alpha value of .05. The One Way ANOVA analysis yielded p-values of .133, .816, and .998 for tasks 1, 2 and 3, respectively. Fig. 7 illustrates the means comparison for each task broken down by interface.

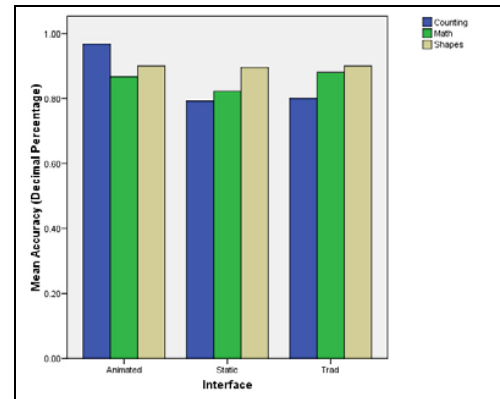


Fig. 7 Means Comparison of Number of Errors

Results show that there are no statistically significant differences in rating of appeal for questions 1 ($p=.253$) and 2 ($p=.069$) related to buttons and arrows, respectively. However, there is a statistically significant interface effect for question 3 which asked how much users enjoyed going from one activity screen to the next ($p = .008$); children enjoyed the animated interface the most. Fig. 8 illustrates the mean rating value for the response to each question on the three interfaces.

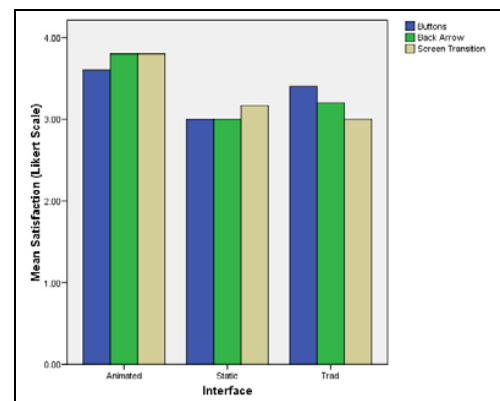


Fig. 8 Means Comparison of Rating Values

B. Task Performance and Appeal by Gender

The results of the Independent Samples t-test show that there are no significant Gender effects for completion time of the three tasks (task 1: $p=.079$; task 2: $p=.333$; task 3: $p=.333$), number of errors made while performing the tasks (task 1: $p=.717$; task 2: $p=.452$; task 3: $p=.966$), and for appeal (task 1: $p=.901$; task 2: $p=.901$; task 3: $p=.803$). Fig. 9 illustrates the mean completion times for the 3 tasks using the 3 interfaces, Fig. 10 shows the mean number of errors while performing the 3 tasks using the 3 interfaces, and Fig. 11 depicts the mean ratings of the survey broken down by question.

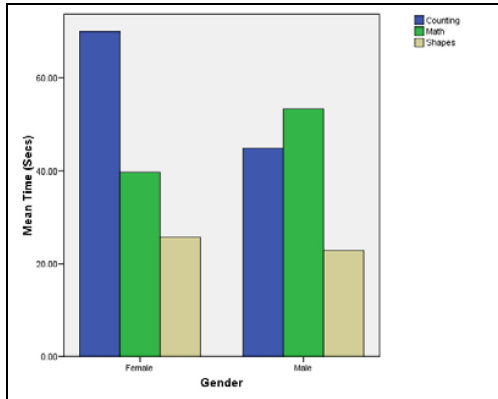


Fig. 9 Means Comparison of Completion Times

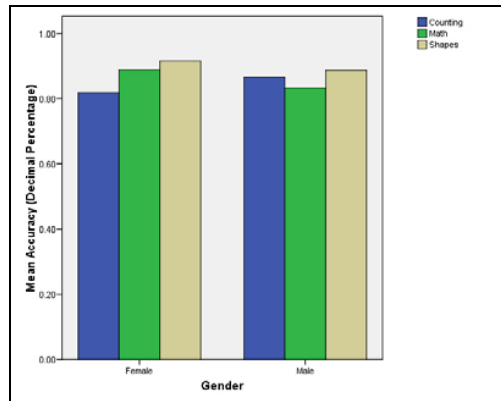


Fig. 10 Means Comparison of Number of Errors

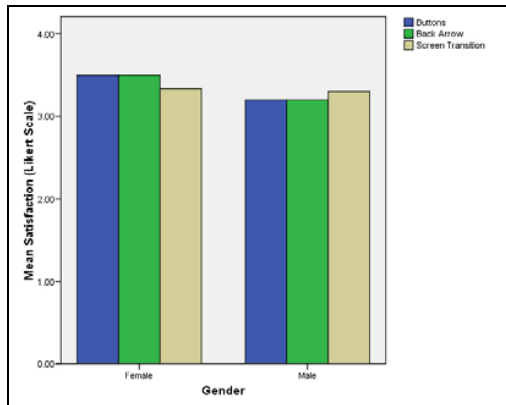


Fig. 11 Means Comparison of Rating Values

C. Task Performance and Appeal by Age

The results of the One Way ANOVA show that there are no significant Age effects for completion time of the three tasks (task 1: $p=.205$; task 2: $p=.749$; task 3: $p=.225$), number of errors made while performing the tasks (task 1: $p=.217$; task 2: $p=.444$; task 3: $p=.869$), and for appeal (task 1: $p=.177$; task 2: $p=.095$; task 3: $p=.486$). Fig. 12 illustrates the mean completion times for the 3 tasks using the 3 interfaces, Fig. 13 shows the mean number of errors while

performing the 3 tasks using the 3 interfaces, and Fig. 14 depicts the mean ratings of the survey broken down by question.

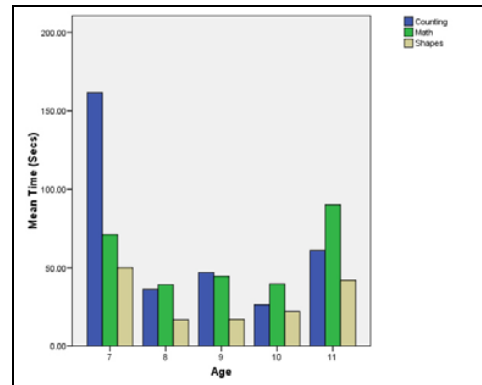


Fig. 12 Means Comparison of Completion Times by Age

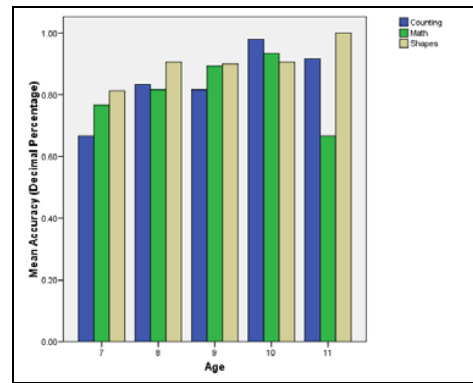


Fig. 13 Means Comparison of Number of Errors by Age

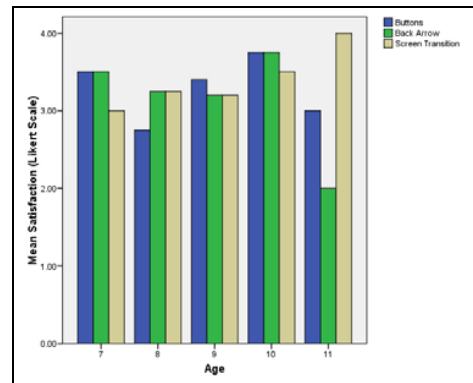


Fig. 14 Means Comparison of Rating Values by Age

V. CONCLUSION

This paper describes three interfaces (two static and one animated) developed for the Mathsigner™ program, and reports the results of a study aimed at comparing children’s use of the three interfaces. Specifically, the study investigated the effects of animation on user task performance and appeal, with the main goal of determining whether an animated

interface seemed most appropriate for the target users and usage context.

Results of the study did not show significant effects of animation on user task performance (measured by activity completion times and number of errors while performing the activities). However, task completion times using the animated interface were consistently lower compared to completion times using the static interfaces. Interface differences were seen in rating of appeal, with the animated interface rated more 'likeable' than the other two because of the smooth transitions between different states. Usability and rating of appeal were not affected significantly by Gender or Age of the subjects.

The comparison of the three interfaces has provided critical data that will inform the final decision on which interface design to adopt in Mathsigner™. The authors believe that more frequent use of these kinds of studies in the development of educational software for children could substantially improve the usability, and thus the effectiveness, of interactive learning applications for K-12 education.

APPENDIX

Available at:
<http://www2.tech.purdue.edu/cgt/i3/interfaces.html>

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