Maddy the mathasaurus: An Interactive math game that introduces the concept and properties of multiplication and designed with consideration for children with ADHD

Mansi Vora
MADDY
THE
MATHASAURUS

an interactive math game that introduces the concept and properties of multiplication and designed with consideration for children with ADHD

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December, 2012
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Mansi Vora
Candidate
Note of Thanks

This Thesis been made possible due to the continual support and encouragement of family and friends. I am very grateful to each and every person who was a part of it in some way or other and thank God for their contribution.

Special thanks to the dedicated faculty at the Rochester Institute of Technology, especially my advisors Chris Jackson, Daniel DeLuna and Dr. Vincent Samar who provided invaluable guidance, support and motivation.
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Abstract

ADHD (Attention Deficit Hyperactivity Disorder) is one of the most commonly diagnosed behavioral disorder in kids, and is estimated to affect about 8–10% of school-aged children. Research shows that out of these children about 26% particularly have Math learning disabilities. The cognitive ability to understand and solve complex mathematical problems requires high level of concentration over a longer duration of time. This ability is disrupted in certain children due to ADHD. Therefore these students are likely to receive lower grades or even failure in standardized measures. However, if an educational environment is created that is specifically targeted towards reducing the disruptive behavioral patterns in these individuals by designing activities that increase engagement time and motivate them to practice mathematical problems, this issue can be addressed effectively.

Apart from therapy and medication, an innovative way of learning would help these children focus and concentrate while enabling them to understand complicated math concepts easily. This project is created to be an interactive educational game built in Adobe Flash, that is geared towards children with ADHD and math learning disability, encouraging them to try a new method of learning and practicing math while having fun with a variety of activities. It focuses on introducing the concept of multiplication through animations, interactive play activities that reinforce that concept and practice section that allows for testing of the knowledge gained. This module is extensible and contains linear and non-linear activities to ensure introduction of concept, guided learning and hands-on practice.

**keywords**  
ADHD, Math Learning Disability, Multiplication, Interactive games, Animations, Flash
Problem Statement

To create an engaging and interactive educational game that serves as a tool to learn and practice Multiplication. To design the project with consideration for special needs children with ADHD and Math Learning Disability.
**Research**

The effects of ADHD on students’ academic performance can greatly limit the cognitive process that needs to take place in order to build a strong academic foundation. This topic has been researched greatly to look more specifically at the effects that ADHD has on mathematical performance. With mathematics being one of the more challenging courses of instruction that students face in their academic careers, it is important to ensure that the students are equipped with the knowledge that they must gain to strengthen their base. The effect of ADHD on mathematical achievement is a major concern given the requirements of mathematics are becoming more stringent, and performance on high-stakes tests often determines whether a student graduates or not.

The main cognitive components involved in problem solving are related to the role of text comprehension and the ability to generate appropriate problem representations. The semantic comprehension of the textual representation of mathematical problems involves most of the cognitive processes necessary to comprehend other types of text and specific knowledge about the meaning of some mathematical terms (altogether, more than, less than, etc.). Problem representation can been described as the construction of a mental model where the information obtained through text comprehension is elaborated in a mental or graphic form. Furthermore, planning processes are necessary in *Arithmetic Word Problem Solving* (AWPS) to maintain the critical information available, and to organize the correct steps to arrive at the solution and implement the corresponding calculation procedures. In all of these processes, working memory plays a crucial role, and this evidence is confirmed by many studies about inhibition processes (Marzocchi et al., 2002; Passolunghi et al., 1999).

*Passolunghi et al.* found that a group of children who had severe difficulties in AWPS, also had lower performance in working memory tasks but not in short-term memory tasks. Additionally, their failure in working memory tasks was associated with a lower recall of target information and a higher recall of irrelevant information.
Zentalletal (1994) are among the first researchers who studied mathematical performance of students with ADHD. In one study with 121 non-disabled boys and 107 boys with ADHD in elementary school, they found that the boys with ADHD demonstrated significantly lower problem-solving ability and conceptual understanding and were also significantly slower in computation. The arithmetic tasks consisted of addition, subtraction, and multiplication tasks.

Results indicated that students with ADHD were slower in number recognition and also in typing numbers, which may relate to visual–perceptual and visual–motor deficits that have been associated with ADHD (Stevens, Stover, & Backus, 1970; Zentall & Krucek, 1988).

Designing a mathematical game considering the cognitive disability towards problem solving and slower number recognition poses a challenge that can be addressed through repetition, visual/graphic clues and longer duration for time-based activities. A reward system would also be designed accordingly to encourage the children to practice more.

A research conducted by Jennifer A. Mautone at the Lehigh University examines the effects of computer-assisted instruction (CAI) on the mathematics performance and classroom behavior of three second through fourth grade students with ADHD. A controlled case study was used to evaluate the effects of the computer software on participants’ mathematics performance and on-task behavior. Participants’ mathematics achievement improved and their on-task attention span increased during the CAI sessions relative to independent seat work conditions. In addition, students and teachers considered CAI to be an acceptable intervention for some students with ADHD who have difficulty with mathematics.
Xu, Reid, and Steckelberg (2002) reviewed research regarding the use of technology with students with ADHD. Xu and colleagues reviewed the characteristics of CAI and suggest that many of the recommended strategies for effective teaching for students with ADHD are often built into CAI. As teachers choose software for computer-assisted instruction for students with ADHD, several considerations should guide selection to ensure student engagement and motivation. Software should have characteristics such as the following:

- Provide step-by-step instructions. Wait for student responses, then provide immediate feedback and reinforcement following responses.
- Allow students to work at their own pace.
- Actively involve students in learning.
- Organize content into small, manageable chunks of information.
- Offer repeated trials using variable formats, as needed, when learning content.
- Offer novel, attention-grabbing approaches when addressing critical content (e.g., introduce new material with graphics, words, and sounds within game formats, animation, or color, or use software to simulate real-world situations with images and sounds).


The study above suggested that keen attention to details like the use of animation, color, images and sounds can result in an effective application geared towards helping ADHD children perform better at the cognitive task at hand. Information designed to convey smaller, repeated chunks of information would lead to better retention value.
One major characteristic of ADHD individuals is the lack of concentration over a longer duration of time. There is a need for designing educational games in a manner that engages these individuals in interesting ways. The moment a game becomes boring there are high chances of ADHD children trying to avoid such activities. The way this can be addressed is through using the principle of keeping the user in the ‘Flow Channel’ and the most effective way of doing so. (refer to Fig 1.1)

More the variation integrated into a challenge and the cognitive ability to successfully perform it, more is the excitement created. A good blend of linear and non-linear activities can help achieve that variation and balance while keeping the user in the Flow Channel. (refer to Fig 1.2)
A balanced integration of instruction and challenging activities could help ADHD children to get enthusiastic about learning the subject matter (multiplication in this case) and apply it to the fun activities following right after. A combination of linear, guided instructions and time-based activities should serve as an effective blend to explain the concept.

Exploring the ideas of ‘groups of’ and ‘rows of’ is an important starting point in the process of learning multiplication. Connecting these ideas to meaningful situations is likewise critical. Students learn best when knowledge is constructed and maintained within a web of related ideas. Representing and communicating those ideas can take many forms – and the simple act of representing them can help to solidify learning for students. In Fig 1.3, John Van de Walle describes five ways to represent any mathematical concept – describing that conceptual understanding comes from exploring the relationships between the representations. The Conceptual Understanding diagram suggests that students should build and represent multiplication using models, connect those models to words and translate them to pictures, write a multiplication number sentence and describe a real-world situation to match. There is great power in being able to translate between these representations.

(Fig 1.3)
# The Project

<table>
<thead>
<tr>
<th>Technical Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Software</strong></td>
<td>Adobe CS5 - Flash, Photoshop &amp; Illustrator</td>
</tr>
<tr>
<td><strong>Scripting</strong></td>
<td>Action Script 3.0, html</td>
</tr>
<tr>
<td><strong>Dissemination</strong></td>
<td>This application will be available over the web</td>
</tr>
<tr>
<td><strong>Audio</strong></td>
<td>Narration and Sound Effect files are integrated in .mp3 format</td>
</tr>
<tr>
<td><strong>User's Age</strong></td>
<td>8 - 9 yrs (Grade 3 students)</td>
</tr>
<tr>
<td><strong>Marketing Target</strong></td>
<td>Parent, Tutors, Instructors, Educational Institutions, and Special Needs Education academies.</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>All</td>
</tr>
<tr>
<td><strong>Technical Requirements</strong></td>
<td>Desktop/Laptop, Internet Browser and Flash Player.</td>
</tr>
<tr>
<td><strong>Technical Knowledge</strong></td>
<td>Must know how to operate the computer and mouse. Parents, Tutors or Instructors and help children set up the site.</td>
</tr>
</tbody>
</table>
**Addressing the Issues**

Intense research on this topic highlighted a couple of specific issues with ADHD individuals that was a result of their characteristic traits that needed to be addressed. Below are some of the facts taken into consideration and their proposed solutions.

<table>
<thead>
<tr>
<th>Facts</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Disability</td>
<td>Create a tool that allows individuals to learn at their own pace. This ensures that even if they miss out on any information due to lack of attention or difficulty in understanding, they can always refer back to the information in its complete form – unlike classroom environment.</td>
</tr>
<tr>
<td>Slower Text Recognition</td>
<td>Engaging visuals and voiceover narration helps to reduce the on-screen text considerably.</td>
</tr>
<tr>
<td>Short Attention Spans</td>
<td>The structure of this project is designed in a way that there is a balance between the learn and play activities. This helps in increasing the interest of the user and strive to keep his/her attention for a longer duration of time. Even if the child misses out on any information, the files can be accessed at any time, at their own convenience. This provides for the much needed flexibility in learning styles.</td>
</tr>
</tbody>
</table>
Design Considerations

The same set of characteristics can be addressed through conscious design decisions. These not only help in enhancing the experience of the tool but also its effectiveness.

<table>
<thead>
<tr>
<th>Facts</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Disability</td>
<td>From a functional standpoint, the application can be designed with the following considerations to address this Issue:</td>
</tr>
<tr>
<td></td>
<td>• Repetition</td>
</tr>
<tr>
<td></td>
<td>• Audio-Visual Feedback</td>
</tr>
<tr>
<td></td>
<td>• Slow Pace</td>
</tr>
<tr>
<td></td>
<td>• Simple UI and Navigation</td>
</tr>
<tr>
<td>Slower Text Recognition</td>
<td>Use of graphical elements instead of work to communicate more effectively.</td>
</tr>
<tr>
<td>Short Attention Spans</td>
<td>The use of animations for introducing various multiplication concepts and engaging interactions in play activities help solve the issue of shorter attention spans. Visual graphics serve as a fun element in keeping the users attention to the activity.</td>
</tr>
</tbody>
</table>
Structure

To maximize its cognitive value, this project has been structured based on various cognitive theories and contain three main sections namely – **Learn** *(introduction of concept)*, **Play** *(guided learning)* and **Practice** *(independent practice)*. (Fig 2.1)
Structure - Flash Timeline

From the execution standpoint, the structure of this project in a Flash timeline is illustrated in Fig 2.2. With distinctly marked labels, external swfs are loaded into the main shell at every frame that contains actionScript.

- Linear Navigation is achieved by loading animations and activities on subsequent keyframes and adding the following event listener to the next button and commanding it to go to a specific frame: `gotoAndStop("labelName");`

- Non-Linear Navigation is achieved in a similar manner by adding the same event listener to the main menu buttons and commanding it to go to a specific topic frame: `gotoAndStop("labelName");`

- Some factors taken into consideration while loading files into the swf holder MovieClip (holder_mc), that is placed on the stage and when the mouseEvent.CLICK is triggered:
  - Clear the swf holder of any previous files: `holder_mc.removeChild(myLoader);`
  - Stop all sounds that are being loaded through external files: `SoundMixer.stopAll();`
  - Go to the selected topic frame: `gotoAndStop("labelName");`

(Fig 2.2)
Structure - Folder and Files

The folder structure of published files is critical to the successful functioning of the main Shell and is demonstrated in Fig 2.3. Swf files containing animations are loading .flv files published from AfterEffects. For interactive files containing narration/instructional audio, the .mp3 files are embedded in the main flash file containing the interactivity.

![Folder Structure](image)

After defining the structure, I wrote down script for the entire project before I started working on animations and interactivities. This helped me to get the files recorded in time for integration and synch the audio to the visuals effectively.

The audio has been recorded in a character voice for Maddy (Fig 2.4), which enhances the fun element of the project. Some children that the application was tested on, even started imitating the voice and retained information that was given through voiceover.
UI and Navigation

An extremely simplified UI and navigation system (Fig 2.5) has been designed so that the entire focus of the user can be on the main content area. Consistent placement of UI elements also help in ease of use. Following is the flow of the application first time through.

Once the user has finished all activities, he/she has the choice to go back to any one of them.

Animated arrows signalling the user that it is time for interaction and ensuring that the user feels oriented, navigating through the application.
UI and Navigation - actionScript

In particular, I faced a challenge figuring out how to use videoEvent handler in order to make it function and show the animated arrow (indicator) only when the animation ended. This was an important functionality in terms of user experience and orientation. I restructured my files and code several times before arriving at the solution. After a lot of research, I found out that in CS5.5 and above the syntax for the videoEvent.COMPLETE was simply Event.COMPLETE and did not function when written as videoEvent.COMPLETE.

Following is the script on the frame of Flash Timeline where the video is embedded in the form of flv playback.

```actionScript
import fl.video.VideoEvent;

// A variable to track if the video has begun playback
var playbackBegan:Boolean = false;
indicator.visible = false;

// A function to handle the video events sent by the listener
function videoHandler(e:Event) {
    indicator.visible = true;
}

// and call the videoHandler function when the event is complete.
theVideo.addEventListener(Event.COMPLETE, videoHandler);
```

Similarly, for the interactive files, the script is included in the last frame of the timeline and the indicator is made visible once the activity on that frame is completed. See Fig 2.7.
Graphic Style

From the initial concept sketches to the final outcome, I transitioned from digital artwork (fig 2.8) to hand-drawn graphics (Fig 2.9) that were scanned and edited in photoshop (Fig 2.10). Several iterations took place before I finalized the visual look of graphics used.

(Fig 2.8)
First iteration of the background and character style was all digital artwork created in Flash. This style looked very 2-D (flat) and did not have a very strong visual appeal. It was good for the prototyping stage but lacked the opportunity to look detailed and finished. This style did not allow me to create depth very easily.

- 2-3 tones max
- Not enough detail
- Ambiguous edges
- Character-background relationship
- Lack of overall cohesiveness

(Fig 2.9)
So I decided to sketch it out on paper and try to create the same environment. I knew this process would be tedious to execute some effects such as parallax scroll for background movement, but the effort would be worth it.
The characters went through the same process of purely digital to hand-illustrated and digital mixed look. You can see in the transition in Fig 2.11 and the difference it made in giving volume to the character in integrating it with the over look and feel of graphics.

Separated elements of the character’s body stored as movie clips enables animation.
Typography

The font-face used throughout the application has been illustrated (Fig 2.12) and converted to a true-type font and is called MTM after the project name – **MADDY the MATHASAURUS**. I looked at many online fonts that would imitate the fun, hand-illustrated and kid-appealing look that I was aiming at with my entire project. After trying various options, I decided to illustrate my own font that would reflect the same texture and look of all other graphic elements used. This helped in further bringing the unified look.

(Fig 2.12)
The main character ‘Maddy’ is a dinosaur with extraordinary mathematical skills and will explain various properties of multiplication through interesting illustrations.

Why Dinosaur as a mascot? – What fascinates kids about dinosaurs is that they like to have imaginary friends who are bigger than them (Larger than life feeling). Dinosaurs provide a sense of power and a seemingly make-believe world that you are allowed to trust in. The average grade-schooler may have only a vague idea when dinosaurs went extinct, but he knows, for a fact, that they’re no longer around. A Tyrannosaurus Rex, no matter how huge and hungry, is thus rendered completely safe, since there’s no chance of accidentally running into one during a nature excursion or at summer camp.

Additionally, no one tells a full-grown Apatosaurus that he has to go to bed, finish his peas before he can have dessert, or take care of his baby sister. Dinosaurs represent the ultimate principle: when they want something, they go out and get it, and nothing had better stand in their way. Therefore, I capitalized on the fascinations of kids for dinosaurs and guide them through math concepts. The children also might tend to feel that the dinosaur is more powerful than their instructors or tutors and a true fantasy friend.
Once the beta version of the project was ready to be tested, I carried out a survey based on experience of users with the application. The testing audience was not confined to children (with or without ADHD) but included professionals in the special needs and educational field, parents, interaction design experts and fellow classmates.

Based on questions asked in 5 main categories, following are the test results with ratings from 1-4 (1 being the highest and 4 the lowest).

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>1</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1.2</td>
</tr>
<tr>
<td>Intuitive Navigation</td>
<td>1.7</td>
</tr>
<tr>
<td>User Friendly</td>
<td>1.5</td>
</tr>
<tr>
<td>Overall Design</td>
<td>1.1</td>
</tr>
</tbody>
</table>

After the initial testing results, I realized that the application was lacking in user orientation, in terms of navigation, and hence I integrated the animated arrow at the completion of each activity to guide the user to desired interaction. This solved the ambiguity of navigational elements. The experience and visual graphics were the strongest aspects of the project.

Some open-ended feedback to the application:

- “Kids will love it! This will surely keep their attention focused and never get bored!”
- “I loved the Associative Property practice game. This is exactly what we are going in class right now!”
- “Maybe more instructions? I initially tried to put the food where the question mark was. Then realized I have to feed it to the dinosaur! And that was awesome!! Super fun to play then, who doesn’t like to feed a dinosaur?! Absolutely stunning artwork.”
- “I love the overall concept and artwork layout of this game. I would definitely play this one over Tetris :P”
- “Loved the voiceover and the music!”
Conclusion

This project has evolved to be a very relevant tool for children to be able to practice multiplication and also have fun with the various interactive games. From the testing results, it is clear that this project has a very strong visual appeal and well balances the aspects of fun and education. It has helped children to focus for a longer duration of time which would normally be more difficult with sitting at a desk with paper and pen, trying to practice multiplication. It is also inspiring for children to think of education as amusing and learn much more in the process of interacting with the application.

I also received feedback from a father who spent long hours creating multiplication flash cards for his daughter so that she could practice random equations. Here is his e-mail response when I sent a link to the application for her:

“Hi Mansi,

Thank you for sending us the links. My daughter will have a lot of fun practicing her multiplication. What a fantastic work this application is! I hope it will be put to good use and help many kids with their learning.”

It gives me immense pleasure and satisfaction that I could use my skills in interactivity and visual design, developed through the course of the Computer Graphics Design program at RIT, towards a good cause.

I have a larger vision for this project and will continue to work on expanding its scope in terms of adding more subject matter to it. The experience I got with user testing and evaluation was invaluable and the findings of this project through the research and implementation stage are highly meaningful to me.
Bibliography

**Articles/Journals/Research Papers**


Brooks, Michael D. *ADD/ADHD: Effects on Mathematics and Mathematical Computations.*


Lucangeli, Daniela, and Silvia Cabrele. “Mathematical Difficulties and ADHD.”
*Mathematical Difficulties and ADHD, Department of Developmental Psychology Padova University, Italy.* 2006.

*Journal of Attention Disorders, Buffalo, New York (2005).* Print.

**Books**


**Websites**

“Developing the Concept - Multi-dig by One-digit Multiplication.” *Eduplace.*


Appendix - Proposal

Thesis Proposal for the Master of Fine Arts Degree

Rochester Institute of Technology
College of Imaging Arts and Sciences
School of Design
Computer Graphics Design

Interactive Math Game for Children with ADHD

Submitted by: Mansi Vora
February, 2012
The game would contain three main sections - Learn, Play and Practice to effectively convey the concept of multiplication.

Learn

This section will introduce the basic concept of multiplication and its various properties through animated videos. It will consist of five sections and will strive to explain the concept through audio-visual stimuli.

Basic Multiplication - Simple animations of numbers appearing on the screen with accompanying audio would read out the equation. Then kids will be asked to repeat the equation verbally (for instance - 2 x 3 = 6 - “Two times three is equal to six.”)
Property of Zero - A visual representation of any number multiplied by zero shrinks down to zero.

Identity Property - Animation of any number multiplied by one retains its value/identity.

Commutative Property - Recognizing that changing the order of numbers in an equation does not change the end value. Whether 3 is multiplied by 4 or 4 is multiplied by three, the answer is going to remain 12. This will be demonstrated by grouping of objects and reversing their order to get the same response.
**Learn Cont.**

**Associative Property** - This section will contain a video of grouping of various objects according to the equation and coming to the conclusion of the same end result. For instance, 

\[ 2 \times (3 \times 5) = 3 \times (2 \times 5) = 5 \times (2 \times 3) = 30. \]

![Diagram](image1.png)

The Learn section will contain frequent repetition of instruction keeping in mind the slow cognitive response of ADHD individuals.

**Play**

This section will require students to interact with different elements on the screen according to instructions given. It is designed to enable students to implement the knowledge they gained in the Learn section through guided responses. Students will get feedback based on the choices they make and the activities will reinforce the application of knowledge gained.

**Basic Multiplication**

**Activity** - Feeding baby dinosaur.

Feeding the dinosaur will include different kinds of food with a number on it. A simple multiplication problem (eg. 2 x 3) will pop up. Children will have to calculate
the two numbers and drag the food with the correct answer into baby dinosaurs mouth. With every response, the dinosaur will grow bigger. There will be feedback on right and wrong responses and the activity will end after 20 correct responses.

**Property of Zero**

**Activity - Avoiding the Zeros.**

This activity will include a dogging the zeros falling from the sky and collecting the other numbers to gain multiplied scores. For instance, if your current score is $x$ and you catch a falling number $y$ (non-zero number), then your score increased by $x \times y$ but if you catch a zero, your score gets multiplied by zero and returns to nil. The game ends in one minute and the challenge is to score as much as you can.

![Image of a number maze]

**Identity Property**

**Activity - Maze.**

In this number maze, kids have to avoid all numbers to remain the self they started off with. If they touch any other number, their core value gets multiplied by that number and their identity changes leading to termination of game. Once they have collected all the 1’s in the maze, the door opens up to the next level. There will be 5 levels increasing in complexity progressively.

![Image of a number maze]
Commutative Property

**Activity** - Placing eggs in the basket.

This activity would include two baskets filled with eggs on the left and two empty ones on the right. Children will have to drag eggs from the picture bank to the empty baskets. The basket will get highlighted once the correct number of eggs have been placed. The end result of this activity will reinforce the two sides to be commutative. \((2 \times 3 = 3 \times 2)\)

![Commutative Property Diagram]

**Associative Property**

**Activity** - Remember the cards.

This activity will be like a memory game. A number will appear on the screen which will be an answer to the numbers being multiplied on two of the cards. The user can see only one card at a time. Once they have calculated all the cards, they have to tick two of them with the same answer and hit check to know if they were right.

![Associative Property Diagram]
The practice section would contain flash cards with random multiplication problems based on the selection of two or three numbers. This will be a time and score based activity where students will have to solve the problems within 30 seconds and after 20 problems they will get a feedback on the number of correct answers out of 20.

The user interface design will be simple and intuitive navigation. The buttons will be large and colorful so that it would make it easier for kids to read. The centre stage will be the area where all the activity takes place. The colors used will be lively but not distracting or too vibrant (saturated) which may cause ADHD students to get restless or hyperactive. Following is a mock-up of the User Interface Design.
Budget

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (in Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing cost for Thesis Documentation</td>
<td>200/-</td>
</tr>
<tr>
<td>Voice artist for narrations</td>
<td>100/-</td>
</tr>
<tr>
<td>Music and Sound Effects</td>
<td>100/-</td>
</tr>
<tr>
<td>Total Estimated Expense</td>
<td>400/-</td>
</tr>
</tbody>
</table>

Constraints of the Project

The scope of my project is focused towards multiplication for grade 3 for now, but will be built in such a way that the code can be extended easily. This can be achieved by loading external swf files into the main shell and using xml to add or remove content with ease.

To make this application accessible to mobile devices, I will export the Flash file as an AIR application that can be installed on them.
Mathematical Difficulties and ADHD - Daniela Lucangeli and Silvia Cabrele

Department of Developmental Psychology
Padova University, Italy. 2006.

This article studies in detail the cognitive problems associated with ADHD and Mathematics in specific as most study and research has been some on linguistic disability in ADHD individuals. A thorough study has been done on calculation and organization skills of ADHD children as opposed to non-disabled children and what stimuli or conditions help ADHD children to perform better.


This journal documents the effect of intervention as part of a pilot project where four elementary schools were randomly assigned to receive one of four interventions:
(a) a school-wide intervention that incorporated universal and targeted treatment
(b) a targeted-school intervention delivered to individual students in regular and special education classrooms
(c) a targeted-home intervention delivered in home and regular classroom settings
(d) a control condition that did not receive a designated intervention.

Results showed that the behavior of disruptive children in all schools improved during the course of the year, with some evidence that interventions provided complementary effects. These findings support the continued use of behavioral interventions in elementary schools and argue for interventions that combine different methods of delivering interventions.
ADD/ADHD: Effects on Mathematics and Mathematical Computations
- Michael D. Brooks
Marygrove College. 2007.

This research discusses the effects of ADHD on students’ academic performance and its effect the cognitive process that needs to take place to build a strong academic foundation. It claims that research has been performed to look more specifically at the effects that ADD/ADHD has on mathematical performance, with mathematics being one of the more challenging courses of instruction that students face in their academic careers. There are environmental and pedagogical interventions that can be engaged to facilitate a process of teaching mathematics to children with ADD/ADHD, which is pivotal to their cognition, meta cognition and overall academic achievement. The research suggests that only classroom instruction is not enough to meet the special needs of ADHD children and that environment of study plays a major role in addressing this situation.

Why Is Math So Hard for Some Children?
- Daniel B. Berch, Ph.D. and Michèle M.M. Mazzocco, Ph.D.

This article in general talks about math anxiety leading affecting math ability. Math anxiety particularly apparent among children who experience academic difficulties with math become more prominent with increased level of difficulty. This might include students with lower working memory capacity, such as those individuals who would have more difficulty doing multistep math because of diminished working memory capacity. Alternatively, these skill deficits might increase the likelihood of experiencing a negative conditioning event and thus, the onset of math anxiety or a more generalized social phobia.
**Books & Other Publications**

**Designing for Children** - Steven Heler and Steven Guarnaccia
Heller and Guarnaccia analyze and celebrate recent advances in child-oriented design and show examples of new work that represent the growing sophistication in this arena. The authors look at hundreds of case studies in which graphics play a major role, specifically in the realms of television, video, and radio; museums and environments; novelties and gifts; toys and games; newspapers and magazines; computers and electronics; theatre and performances; and books and posters. Packaging and promotional materials for the various products and activities are also discussed.

**Growing Graphics** - Vicky Eckert, Efrén Zúñiga, Ana Freixas
Essentially simple but incredibly powerful this collection of graphics gives us access to the visual universe of the child. It’s a special world that revolves around a group of indescribable ingredients and characteristics, all of which inspire the interest and emotions of the very young. Growing Graphics features products that have been designed not only to appeal to the child, but also to meet with the approval of parents. It is divided into sections by age: 0-3 yrs, 3-6 yrs, 6-9 yrs and 9-12 yrs. This book covers a lot of information you might want to know about marketing to kids and their parents.

**The Art of Game Design** - Jesse Schell
The Art of Game Design: A Book of Lenses shows that the same basic principles of psychology that work for board games, card games and athletic games also are the keys to making high quality video games. Good game design happens when you view your game from many different perspectives, or lenses. This book gives the reader one hundred of these lenses - sets of insightful questions to ask yourself that will help make your game better. These lenses are gathered from fields as diverse as psychology, architecture, music, visual design, film, software engineering, mathematics, writing, puzzle design, and anthropology.

The purpose of this investigation was to evaluate the relative efficacy of two consultation-based models for designing academic interventions to enhance the educational functioning of children with ADHD.


Attention deficit hyperactivity disorder (ADHD) article on PubMed Health discusses the causes, symptoms, treatment and prevention of ADHD.

The Sage Journals - http://jad.sagepub.com/content/9/1/301.short

The Effects of Computer-Assisted Instruction on the Mathematics Performance and Classroom Behavior of Children With ADHD. The journal talks about the effects of computer-assisted instruction (CAI) on the mathematics performance and classroom behavior of three second-through fourth-grade students with ADHD. A controlled case study is used to evaluate the effects of the computer software on participants’ mathematics performance and on-task behavior. Participants’ mathematics achievement improve and their on-task behavior increase during the CAI sessions relative to independent seat work conditions. In addition, students and teachers consider CAI to be an acceptable intervention for some students with ADHD who are having difficulty with mathematics. Implications of these results for practice and research are discussed.

A reference to this site is made to show what kind of interactivities are available for children to practice math online. Though the graphics may be colorful, the only interactivity is clicking the radio button for the correct answer which can get monotonous for children and specially for attention deficit individuals.


This site discusses 12 Ways to boost test scores for children with ADHD and Learning Disabilities. It gives suggestions for organizing schedule and tips on how to handle major exams.

Introducing Multiplication for Grade 3 - http://plato.acadiau.ca/courses/educ/reid/elem-math-virtual-workshops/Multiplication/IntroducingMultiplication.htm

This site was a good reference on how to introduce the concept of multiplication using real-life examples and story telling.


Math Steps was a good reference to introducing the concept of multiplication.
**Thesis Timeline**

by Mansi Vora

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATES</td>
<td>7 - 13</td>
<td>14 - 20</td>
<td>21 - 27</td>
<td>28 - 3</td>
<td>4 - 10</td>
<td>11 - 17</td>
<td>18 - 24</td>
<td>25 - 1</td>
</tr>
<tr>
<td>Milestones</td>
<td>Proposal accepted</td>
<td>Flow chart finished</td>
<td>Web site started</td>
<td>1st committee meeting</td>
<td>Content finalized</td>
<td>Storyboards done</td>
<td>2nd committee meeting</td>
<td>1st prototype done</td>
</tr>
<tr>
<td></td>
<td>Document Project</td>
<td>Literature Review</td>
<td>Research Content</td>
<td>Develop Working Prototype</td>
<td>Develop Content Outline</td>
<td>Create Storyboards</td>
<td>Testing/ Feedback</td>
<td>Complete Beta Version of Project</td>
</tr>
</tbody>
</table>

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**Literature Review**

**Write Abstract**

**Flow Chart**

**Create Storyboards**

**Thesis Web site**

**Committee Meeting**

**Committee Meeting**

**Committee Meeting**

**Committee Meeting**

**Committee Meeting**

**Committee Meeting**

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**Thesis Show - November 15, 2012**

**End of Winter Quarter**

**Mid Quarter**

**End of Spring Quarter**

**Thesis Defense (Oct 26, 2012)**

**Graduation**
Appendix - Illustrations
### Appendix - Voiceover Script

**Narration Script Document**

Please narrate the script deliberately SLOW so that kids can understand.

<table>
<thead>
<tr>
<th>File name</th>
<th>Script</th>
<th>Duration</th>
<th>Accompanying Visual</th>
<th>Other Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intro_audio.mp3</td>
<td>Hey there! I am Maddy.... I am called a “Mathasaurus” because I know everything about math. Wanna be friends with me? I will teach you math in a fun way....So are you ready for the challenge? Let’s begin with Multiplication!</td>
<td>15 sec</td>
<td>Animated clip of Maddy talking to the kids.</td>
<td></td>
</tr>
<tr>
<td><strong>Basic Multiplication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1_audio.mp3</td>
<td>‘BASIC MULTIPLICATION’</td>
<td>40-45 sec</td>
<td>Corresponding visuals of equations.</td>
<td>Text in red to be narrated a bit slowly. Titles to be narrated at the beginning of each module.</td>
</tr>
<tr>
<td></td>
<td>What is Multiplication? It is when one number is scaled by another number. Think of it in terms of groups .... Lets take an example...10 times 2 is equal to 20. You can break this equation as ... 2 groups of 10 objects results in 20 objects. Similarly 4 times 3 is equal to what? {Pause for 2 secs for kids to think} 3 groups of 4 pebbles sums up to 12 pebbles. So repeat after me...”4 times 3 is equal to 12&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>File name</td>
<td>Script</td>
<td>Duration</td>
<td>Accompanying Visual</td>
<td>Other Comments</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------------------------------</td>
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<td>---------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Property of Zero</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2_audio.mp3</td>
<td>'PROPERTY OF ZERO’</td>
<td>40-45 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The POWER of Zerooooo!!!!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ANY number multiplied by zero becomes zero.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Even the two fat ladies {88} cannot match up to his strength.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>88 times 0 is equal to zero.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a pretty egg into zero is zero...nah..just kidding!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SO remember kids...whenever you encounter a ZERO in simple multiplication, you know what the result is going to be......Zero!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>A very powerful manly voice to imitate the character of Zero.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Text in purple to be read very casually...as a joke.</td>
</tr>
<tr>
<td><strong>Identity Property</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L3_audio.mp3</td>
<td>'IDENTITY PROPERTY’</td>
<td>35-40 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The pretty lady &quot;ONE&quot; is exactly the opposite of Powerful Zero. It does not change the value of that number... instead it becomes that number. Therefore ANY number multiplied by one remains the same.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>20 times 1 is equal to 20.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In terms of groups...one group of 20 pebbles is equal to 20 pebbles.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>So repeat after me... &quot;Any number multiplied by one remains itself&quot;</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Slow narrations for visuals to be synched correctly.</td>
</tr>
</tbody>
</table>
### Commutative Property

**File**
- L4_audio.mp3

**Visual**
- ‘COMMUTATIVE PROPERTY’

**Comments**
- It is not complicated at all. Commutative Property simply means that even if you change the order of numbers that you are multiplying, the result will be the same.

For example:
- 2 times 3 is equal to 6 and 3 times 2 is also equal to 6.

Therefore 2 x 3 is the same as 3 x 2.

Now you know u can mess around with the order...huh!

**Duration**
- 30-35 sec

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### Associative Property

**File**
- L4_audio.mp3

**Visual**
- ‘ASSOCIATIVE PROPERTY’

**Comments**
- This is similar to commutative property but it involves more than 2 numbers.

Lets make it simple...switch the number of eggs in the basket and when you multiply them, the answer will remain the same.

2 times 3 into 5
- \{2 \times (3 \times 5)\} is the same as 3 times 2 into 5 which is equal to 5 times 3 into 2

The result of all three equations is 30.

So now you know u can mess around even more.

**Duration**
- 30-35 sec

**Equations**
- Equations will accompany a visual showing number of eggs being switched
<table>
<thead>
<tr>
<th>Activity 1 Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1_audio.mp3</td>
</tr>
<tr>
<td>Multiply the two given numbers. Drag the food with correct answer to Baby Dyno's mouth and feed him.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity 2 Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2_audio.mp3</td>
</tr>
<tr>
<td>Avoid the zeros and make the maximum score by collecting other numbers. If you collect a zero, your score will get multiplied zero by and you will start from scratch. You have one minute to score as much as you want.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity 3 Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3_audio.mp3</td>
</tr>
<tr>
<td>Maintain your identity till the end by collecting only 1's from the maze. Touching any other number will change your identity and terminate the game.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity 4 Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4_audio.mp3</td>
</tr>
<tr>
<td>Complete the equation by dragging the correct number of eggs on the right side of the &quot;equal to&quot; sign.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity 5 Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5_audio.mp3</td>
</tr>
<tr>
<td>Select the cards with equations that result in the answer shown on the screen. You must get rid of all the cards to complete this activity successfully.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fcard_audio.mp3</td>
</tr>
<tr>
<td>Time to practice! Are you ready? You have 30 seconds to solve each equation.</td>
</tr>
<tr>
<td>Fcard_audio.mp3</td>
</tr>
<tr>
<td>You have 40 seconds to solve each equation. All the best!</td>
</tr>
</tbody>
</table>

Positive Feedback:
1. PFb1_audio.mp3 - Excellent!
2. PFb2_audio.mp3 - Very Well Done!
3. PFb3_audio.mp3 - That's Correct! Yay!
4. PFb4_audio.mp3 - Fabulous!
5. PFb5_audio.mp3 - Superb!
6. PFb6_audio.mp3 - You are doing great...keep it up!

Negative Feedback:
1. NFb1_audio.mp3 - No worries...try it again.
2. NFb2_audio.mp3 - Uh oh...that's not the right answer
3. NFb3_audio.mp3 - You can do better
4. NFb4_audio.mp3 - You are almost there
5. NFb5_audio.mp3 - Keep trying...don't give up.