Force Feedback-Based Learning for Dyslexic Student.

By

Ng Kah Keat

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF INFORMATION TECHNOLOGY (HONS)

COMPUTER SCIENCE

Faculty of Information and Communication Technology

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DECLARATION OF ORIGINALITY

I declare that this report entitled "Force Feedback-Based Learning on Dyslexic Student" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : _____

Name : _____

Date : _____

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisors, Dr. Manoranjitam who has given me this bright opportunity to engage in an ICT design project. It is my first step to establish a career in IC design field. A million thanks to you.

To a very special person in my life, Melissa Lee, for her patience, unconditional support and love, and for standing by my side during hard times. Finally, I must say thanks to my parents and my family for their love, support and continuous encouragement throughout the course.

ABSTRACT

Force Feedback-Based Learning on Dyslexic Student.

Ng Kah Keat University of Tunku Abdul Rahman, Kampar Perak.

I assessed the teaching techniques of the PDM or Persatuan Dyslexia Malaysia and suggested ways to improve the teaching process. Haptic Technology enables Force Feedback which recreates sensations such as texture by producing forces such as vibrations, weight or even motions to the user. The mechanical stimulation is used to create simulations of virtual objects in a computer simulation. In this study, dyslexic students between age 3 and above have been studied and investigated with Persatuan Dyslexia Malaysia (PDM). Through an interview and on-site observation, the current existing educational teaching format does not have any special techniques that differentiate it from regular traditional methods. Thus in this study, a computer-based software or applications incorporating force feedback that produce various texture as a design element is being developed and to be used to aid the process of learning of dyslexic students. The research-based application will give out an illusion of force feedback encouraging the process of learning and provide convenience to the teachers.

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LIST OF ABBREVIATIONS

PDM	PERSATUAN DYLEXIA MALAYSIA

CHAPTER 1: INTRODUCTION

1.1 Introduction

The title for this project is Force Feedback Based Learning for Dyslexia Student. Force feedback can be defined as the physical sensation of resistance, a property being integrated into virtual reality. Whereas, Dyslexia is a disorder involving trouble in read and recognizing symbols, words or even letters. Hence, the title can be interpreted as a method to smoothen the learning process of students that have difficulty in identifying words and symbols with physical sensation of resistance.

Force Feedback is the combination of two words “Force” and “Feedback”. The term Force Feedback can be clarified as a simulation of physical attribute such as weight and resistance. In this case, when the student exerts force into an object, the student is able to feel different sensation. Some examples of technology today that uses force feedback are controllers, steering wheels, gamepads and joysticks. The objects will vibrate or moves at appropriate points.

With that in mind, we can implement and correlate force feedback method into learning process of dyslexic students. The purpose of this project is to improve the learning process of dyslexic students

According to American Dyslexia Association, dyslexic Students are people with a disorder that have difficulty and inaccurately recognizing symbols, words or even letters. A healthy person is capable of learning how to read, write and listen easily whereas a dyslexic person has difficulty learning how to perform such task. It is estimated that 1 out of 10 people have dyslexia. Dyslexia does not associate itself with ones IQ, for example Einstein was dyslexic but he had an IQ of approximately 160.[1] We can conclude that dyslexic students are neither lazy or poor intelligence.

According to American Dyslexia Association A normal student is able to master or pickup languages and symbols easily when taught in the traditional ways.[1] Whereas dyslexic students just need proper guidance or different alternative methods of learning. The project’s goal is to create a method of learning through force feedback for dyslexic students so they can have an alternative way to grasp necessary skills and boost their leaning capacities.

1.2 Problem Statement and Motivations

The current learning application for dyslexic students are not incorporating touch sensation thus learning becomes a challenge for them. Through literature review on site requirement gathering and interviews, dyslexic students are observed to use similar methods and techniques as normal students during learning process. Another element should be implemented and incorporated to help the students.

Most applications are not specifically designed for students that suffer from dyslexia. Each app is developed to satisfy a target audience needs. Currently, most education applications are designed for normal children and does not take into consideration for dyslexia students. Application that are targeted at dyslexic kids does not incorporate touch sensation. Touch sensation and force feedback has little to none prior work, there is no research which type of sensation is suitable for the students. This project aims to research on what type of sensation is suitable for the dyslexic kids as a learning element.

Dyslexia shaming is very common among parents and teachers. When you're at school, you are expected to be able to do something at a certain age. Dyslexic students might find it hard to learn how to read or write. When a dyslexic student is unable to read, write or keep up with others, they will feel worthless or unworthy, hence leaving an emotional wound. Based on literature review, most applications for learning for dyslexic students are unattractive and not up to date. Some even fail to address the difficulty in learning for dyslexic students.

1.3 Background Information

Dyslexia is a common learning difficulty that affects people all around the globe. One that suffers from dyslexia have difficulty in recognizing symbols, letters, patterns and even alphabets. People that is dyslexic is not to be confused with down-syndrome as they have a normal IQ.

Previously, a research on haptic touch conducted by Lim Kok Ooi, previously undergraduate student from University Tunku Abdul Rahman has shown positive results and it is proven beneficial for dyslexic students between toe age 3~8

This research will be conducted based on force-feedback by using the Phantom Omni, a tool that is able to produces various texture by giving out an illusion of touch sensation.

1.4 Research Objectives

The research objective has 3 different components.

1. **To study the touch sensitivity of dyslexia students.**

A research through visiting or interviewing will be conducted to observe and investigate children's touch sensitivity on objects.

2. **To propose a suitable touch sensation learning experience for dyslexia student**

A model will be developed and designed with appropriate elements to improve and investigate the relationship between touch sensation and the learning efficiency of dyslexia students

3. **To validate the proposed touch sensation through learning application development.**

A prototype will be developed and will be used to test dyslexia students. Observe the students and record the changes in learning progress of the students.

1.5 Proposed Approach

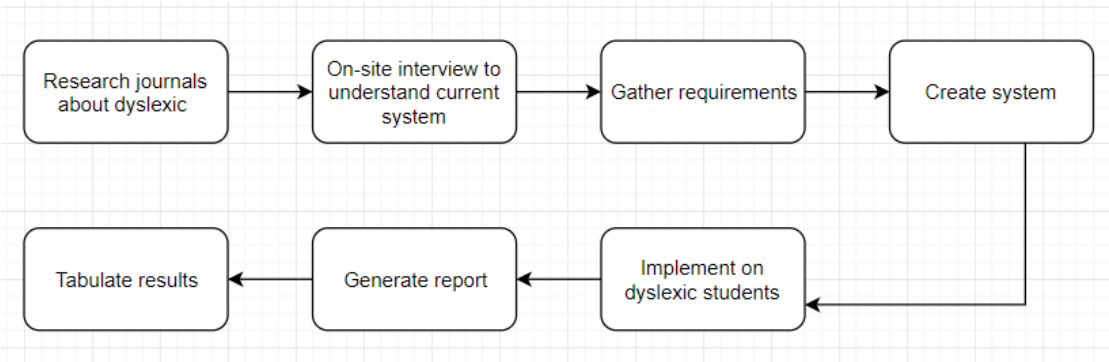

Figure 1.1

Firstly, researching on journals about dyslexic in general is done for a basic understanding about dyslexia. After that, an on-site interview session is conducted with Persatuan Dyslexia Malaysia (PDM) to analyze the current system and gather requirements.

Next, the system is designed and made according to the objective. After that, a visit to Persatuan Dyslexia Malaysia (PDM) is done to implement the system. The results are tabulated.

1.6 What have been achieve

1. Successfully study the touch sensitivity of dyslexia students.

By observations and interviewing process, requirements have been gathered to study the sensitivity of dyslexia students.

2.Proposed a suitable touch sensation learning experience for dyslexia students.

By observing daily objects that are used by dyslexia students, 5 sensations are proposed for further testing. The sensations include viscosity, vibration, constant force, friction and spring.

3.Validated the proposed touch sensation through learning application development for dyslexia students.

On site visiting and analyzing data was done to further validate proposed touch sensation.

1.7 Report organization

This report contains five main chapters which is introduction, literature review, system design, proposed method and conclusion.

Chapter one mainly focuses on the background of the project. This chapter also includes a general explanation on the problem statement objectives proposed approach and the result of this project.

Chapter 2 discusses about previous works and literatures. This chapter showcases the strength and weaknesses of the functionalities of previous works.

Chapter 3 highlights the system design of the project. The details of the project are projected with framework, flowcharts and activity diagrams.

Chapter 4 will be about Data collection, a chapter solely about data that has been collected through interview and observation process.

Chapter 5 is “testing and results”, this chapter emphasizes about the achievement of objectives of this project.

Chapter 6 wraps up the project with a conclusion. No further ideas or discussion is added here Contributions and future works are included in this chapter.

CHAPTER 2 LITERATURE REVIEW

2.1 Literature Review

The word dyslexia is derived from two Greek words: *dys* (inadequate or lack of) and *lexicon* (word and/or verbal language). Dyslexia thus means problems learning how to read words and deal with language in print.[6] Dyslexia is a specific learning disability characterized by difficulties with word recognition, spelling, and decoding. People without reading disabilities process a word instantly and can automatically access the definitions of words as they read. In contrast, those with dyslexia experience reading as a slow, laboured, and error-prone activity. [3] Factors to consider when approaching dyslexia students are the context, the assessment, the curriculum and the learner. [5] The principles to for a specialist teaching program for the dyslexic are the structure, the multi-sensory element, be reinforcing, include skill training and incorporate metacognitive aspects.[5]

According to Dyslexia center of UTAH, one in five students, or 15-20% of the population, has a language-based learning disability. Dyslexia is the most common of the language-based learning disabilities.[7] But most students do not even know they are dyslexic. Currently, they are very little applications that are used to aid dyslexic students in learning how to read and learn the alphabet in early stages in education. Most of the applications are not well designed and is often targeted at normal students rather than dyslexic students, according to Janie Martin Consultant for students and adults with dyslexia, some of the example of applications used in early stages of learning are “Sound literacy “, “Dyslexia Quest “and “Starfall Alphabet”. As students grow older, apps such as “Google Keyboard” and “Google Playbooks” are used.[8].

According to Robbin Collinge, factors when designing for the dyslexic are the typography [9]. Font is especially important when designing an app for the dyslexic community. It affects the perception of shapes and look of alphabet, thus affecting the learning efficiency for the dyslexic. Besides that, the layout must be as clear as possible. This is to ensure that the user can view and understand the interface. When designing, 80 characters per line as narrower makes it easy for reading.[9]

Rather than a disease or an intellectual defect, for which it is often misunderstood, dyslexia is a language-based disability.[14]The brains of dyslexic children work

differently from normal children and, hence, they require different teaching techniques. They require more stimulation[15].Class teachers may be particularly confused by the student whose consistent underachievement seems due to what may look like carelessness or lack of effort[20]. Mastering reading and writing skills as the key priority for students who experience developmental disorders reading and writing or dyslexia. Learning language for dyslexic students is not easy, dyslexic students have difficulty processing language components, especially in reading and writing. ICT is a great tool to aid students to achieve literacy.[7] Past research has shown that touch sensation has shown that dyslexic children are excited and able to stay focus to learn basic alphabets using the developed applications.[7 8] However, the studies does not emphasize the type of sensation or force feedback that is suitable and can stimuli the best response from the students.

Dyslexia is the most common of the language-based learning disabilities.[9]But most students do not even know they are dyslexic. Dyslexia is not a disease but a lifelong condition. The symptoms of this condition are variable from one child to another, but usually, the child has normal or above average intelligence.[16]Currently, they are very little applications that are used to aid dyslexic students in learning how to read and learn the alphabet in early stages in education. Most of the applications are not well designed and is often targeted at normal students rather than dyslexic students, according to Janie Martin Consultant for students and adults with dyslexia, some of the example of applications used in early stages of learning are “Sound Literacy “, “Dyslexia Quest “and “Starfall Alphabet”. As students grow older, apps such as “Google Keyboard” and “Google Playbooks” are used[10].

According to Robbin Collinge, tools are also important when designing app for to make it as clean as possible. Tools such as adjusting size of font, font style, padding, lining and color is important so that the user is able to set his or her preference on the app. [9] Audio Reading can also be implemented to aid users who struggle with reading [9]. Lastly the navigation, the path on the platform should be flexible and kept logical.[9]

2.2 Projects for dyslexic

1. Sound Literacy

Sound Literacy This app contains tiles of individual letters and numbers. Developed by a teacher, it is recommended by teachers and tutors around the world as it aids in their teaching. While it is a great app for learning sounds, processing words and learning spellings, it still does not replace a teacher. The app does not come with an autocorrect feature, and it basically bridges the gap between a student and a teacher. [2]

Figure 1 shows screenshots of Sound literacy app, this app allows learning through sections or parts of words.

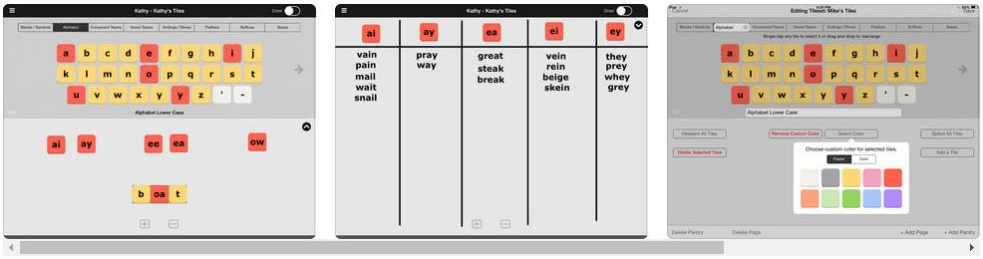

Figure 2.1

2. Dyslexia Quest

Dyslexia Quest is created in order to look like an interactive game while evaluating your working memory, phonological awareness, processing speed, visual memory, and auditory memory and sequencing skills. The Yeti Master is also there to guide you on the signs of dyslexia as you play along and move ahead in the game. [2]

Figure 2 shows screenshots of Dyslexia Quest, this app allows students to play games while learning. The game will evaluate your progress and record it.

Figure 2.2

3. What is Dyslexia?

From the makers of Dyslexia Quest, What is Dyslexia is another great app that is available completely free of cost. It talks about the journey of a common dyslexic, with a video comic that depicts how he spends his entire day. It also includes a quiz to see if you have dyslexia. It contains tips to handle a dyslexic child at home and at school for the help of both parents and the teachers. [2]

Figure 3 shows screenshots of "What is Dyslexia?" This game is a series of comics to educate parents or teachers and even students to treat a dyslexic student. This application does not help the user to study more efficiently but it allows others to create a better environment of study for the dyslexic.

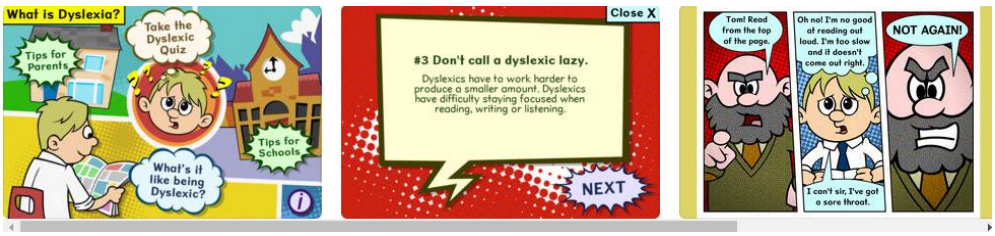

Figure 2.3

4. Draw Something

Like Pictionary, this game gives you a word to draw out for other players to guess. You get many colours and tools with which to draw, but you're timed, so draw fast!

Figure 4 shows screenshots of "Draw Something". Draw something is a fun and interactive game that allows students to draw something and another student has to

guess it. This app will help dyslexic students to remember and learn new words while allowing them to practice drawing shapes or symbols.

Figure 2.4

5. Starfall ABC

Children delight as they see, hear, and interact with letters and sounds in words, sentences, and games. They learn to recognize letters and develop skills that will ensure they become confident leaders.

Figure 5 shows screenshot for “Starfall ABC” , this game aids in early learning process of the alphabet.

Figure 2.5

2.3 Strengths and weaknesses

1. Comparison Table

Application	**Platform**	**Target User**	**Language**	**Interaction**	**Touch Sensation**
Sound Literacy	ipad/ tablet	Adults / Guardians	English	Offline	No
Dyslexia Quest	IOS application	Dyslexic Kids	English	Offline	Yes
What is Dyslexia	ipad	Adults / Guardians	English	Offline	No
Draw Somethir	IOS application	All	English	Multiplayer Online	No
StarFall ABC	ipad	Normal Kids	English	Offline	No

Table 2.1

2. Strength and weakness table

Application	**Strength**	**Weakness**
Sound Literacy	-Learning Words -User Friendly -Uses Sound to interact	- No Vibration / Forces interaction
Dyslexia Quest	-Vibration -Attractive -User Friendly	- No Learning Alphabet
What is Dyslexia	-Educates Adults -Comic Strips	- No Vibration / Forces interaction - Does not help dyslexia student in educati - No Learning Alphabet
Draw Something	-Multiplayer Games -Teaches Drawing -Enhance Creativity -Students can play with Teachers	- No Vibration / Forces interaction - No Sound interaction - No Learning Alphabet
StarFall ABC	-Teaches Alphabet -Easy to understand -User Friendly	- No Vibration / Forces interaction - No Sound interaction

Table 2.2

CHAPTER 3: SYSTEM DESIGN

3..1 Activity Flow Diagram

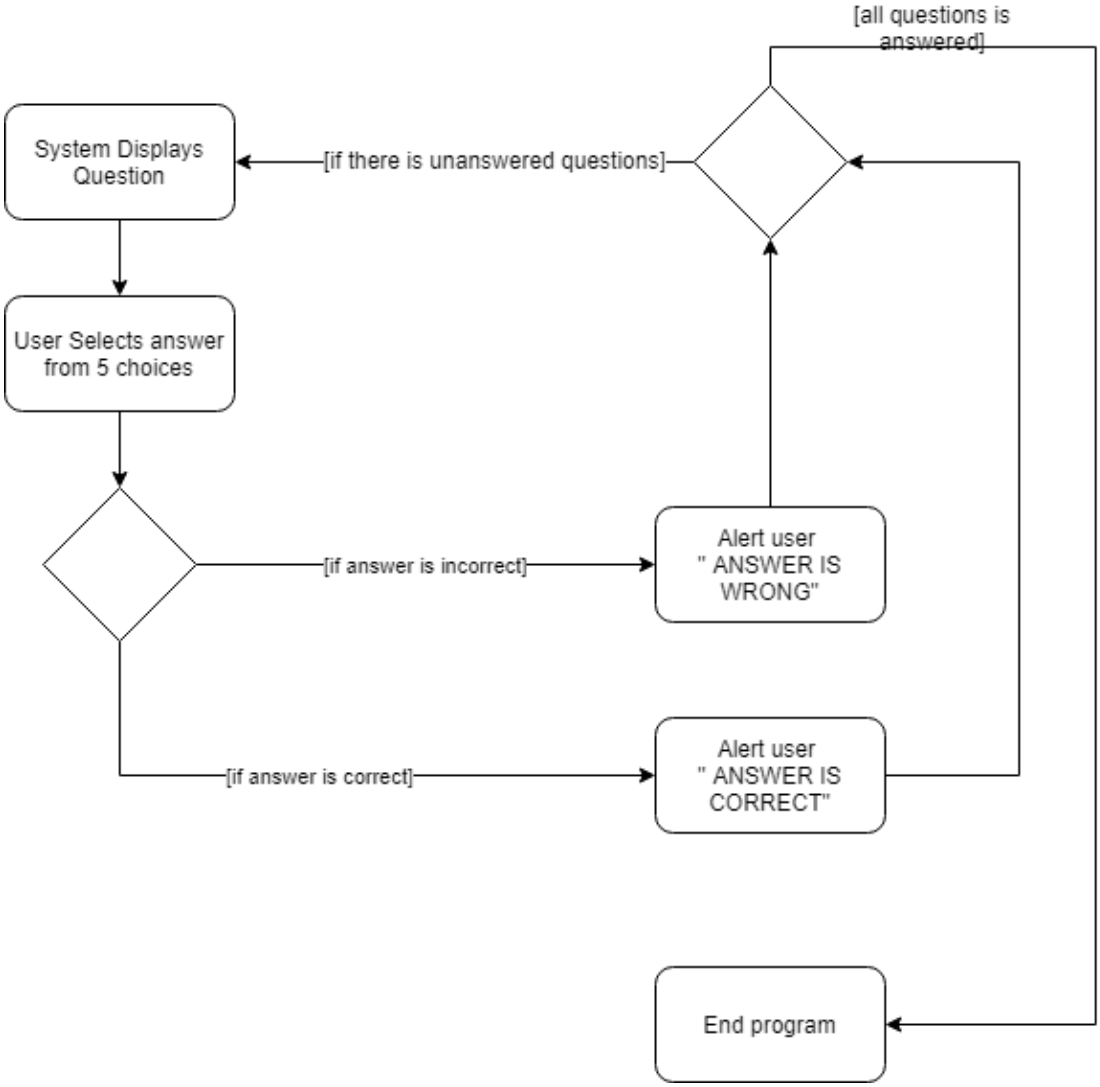

Figure 3.1

The system displays a questions, a random sensation is set. The dyslexic student is then asked to feel the sensation. After that, 5 different sensation or texture is displayed. The dyslexic student is then asked to match the sensation. When the dyslexic user answers the question, the system will prompt an alert message to notify if the student answered it correctly or incorrectly. The system will continue asking questions until all questions is finished answered.

3.2 Use Case Diagram

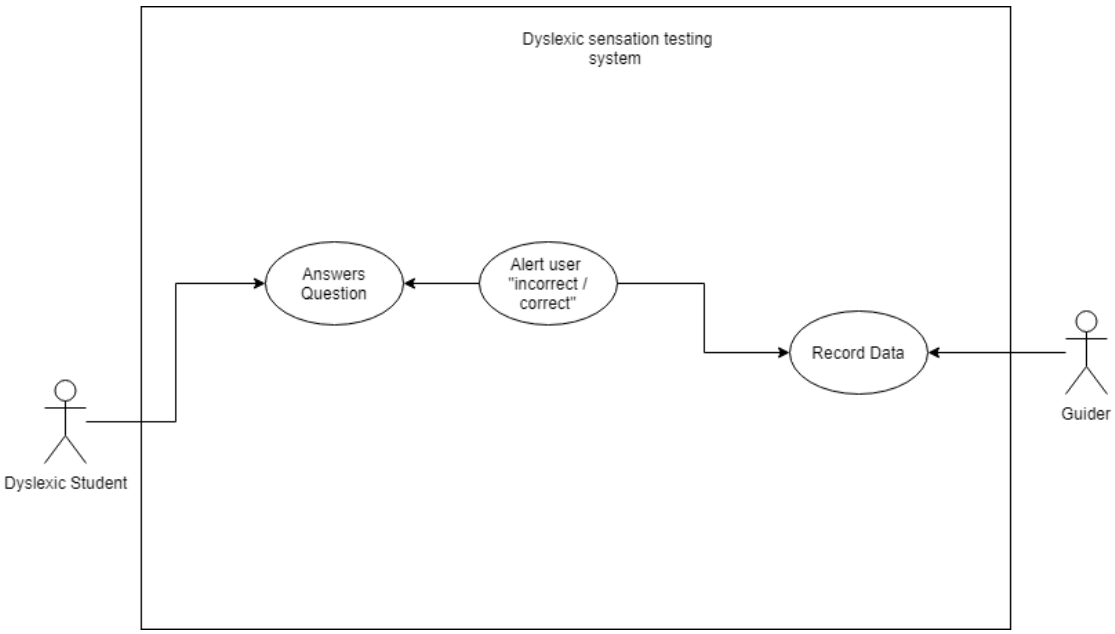

Figure 3.2

A guider first introduces the Phantom Omni to the dyslexic student, first the dyslexic student is introduced to all 5 different kind of sensation. Once they recognize the sensation, the student is then asked to answer 10 questions. The guider will then record the data such as expression, accuracy and speed of the student when answering the questions.

3.3 Game Design

I. Alphabets for future work

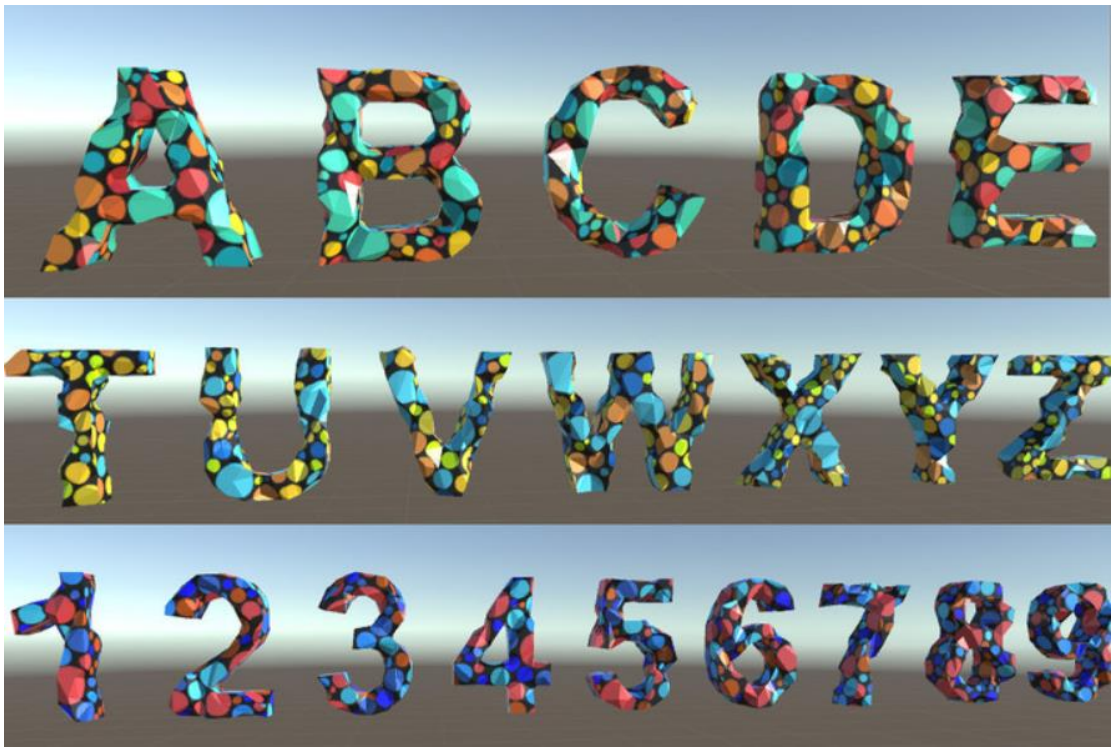

Figure 3.3

When using the Phantom Omni, participants are able to feel the object texture. A game will be created to research what type of sensation is will stimulate a better response from the participants.

Figure 3.4

This Scene was used to let the participants get a grasp of the motor skills and learn how to use the Phantom Omni. They were given 5 minutes to move around and feel or touch the objects

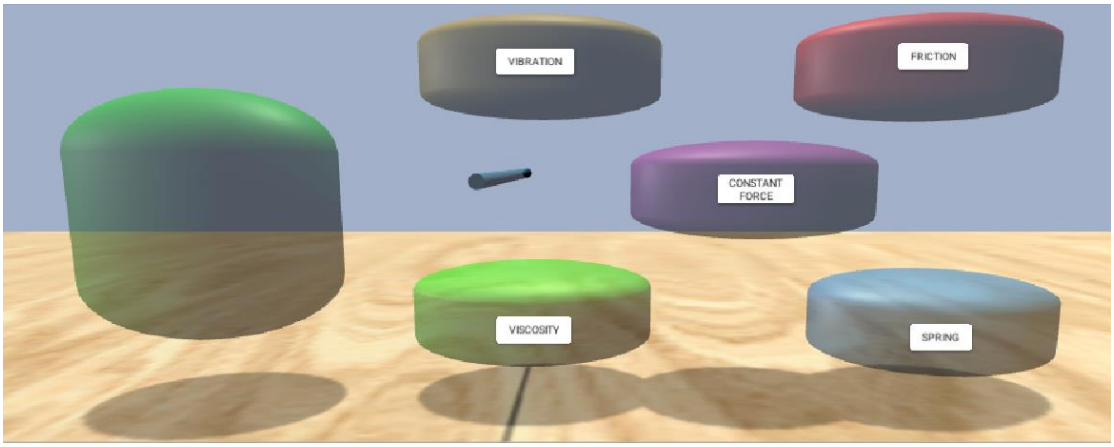

Figure 3.5

Different sensation will be felt by the student ,it is produced by the Phantom omni when the stylus touches the object. The participants were then instructed to match the sensations.

3.4 Tools Used

1. Phantom Omni

The Phantom Omni is a commercial, portable haptic device with six Degrees of Freedom (DoF) developed by Sensable Technologies. It is based on a serial architecture, which means that the handle is connected to the housing by a single serial chain. The device evolved from research done by Thomas Massie and Dr. Kenneth Salisbury at MIT. [4]

Figure 3.6

2. A Computer or Laptop (Windows)

A computer or laptop is needed to run the application. The computer must be able to support the Phantom Omni and the application created by using Unity.

Figure 3.7

3.5 Implementation Issues and Challenges

1.Difficulty in finding target testing users.

Students that are aged between 3~12 that suffer from dyslexic is hard to come by. Contacting schools to enquire about number of dyslexic students is a huge challenge for this project.

2.Lack of cooperation and understanding from schools.

PDM Penang had very little cooperation on this project , he did give permission to visit them to gather requirements. Instead he gave his permission to test the application in his school. This contradicts with my methodology for this project , hence I had to search for another school.

3.Finding a suitable platform to create the software.

Through research , I have found out that unreal engine and unity is used to create games.Unreal engine uses C++ code while unity uses C# code. I have experience in C++, so I decided to use unreal engine , unfortunately I couldn't find plugin or dll file to connect the phantom omni with unreal engine. Hence, I had to change to unity midway.

4.The driver issue

To use the phantom omni , a driver has to be installed. A cd was included when I receive the Phantom Omni, Unfortunately, my computer couldn't properly support the driver. I had to find and download another driver.

5. New to C#

C# and unity is especially challenging to master as I had no notes , no experience or practical classes for codes.

6. The hardware issue

One of the button on the stylus of the phantom omni is not working properly, hence during the code. Therefore ,I had and will change the button to a keyboard input instead. This will greatly influence and affect the user experience.

1.2.3 Tools

3.6 Methodology

Waterfall development methodology will be used to develop this software.

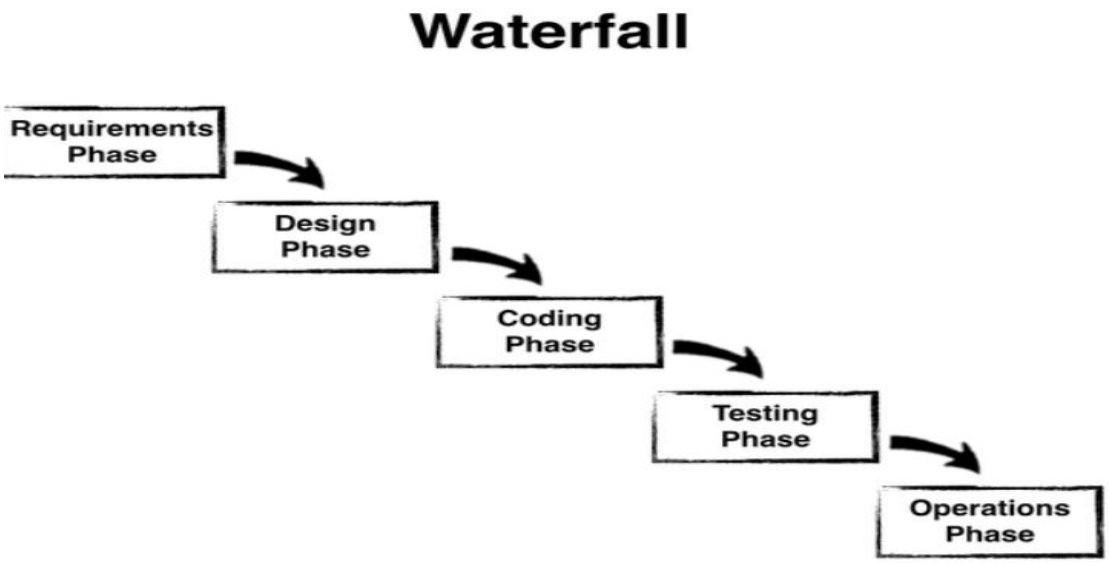

Figure 3.8

Firstly, in the requirements phase, research through the internet or on-site interviewing will be conducted to fully understand the current teaching method on dyslexia students.

Secondly, the design phase. Unified modelling language or UML Diagrams will be created to visually represent the application. This is to allow better understanding, alter and document the system.

Thirdly, the coding phase. Each unit will be hard-coded and tested for its functionality based on the requirements.

After that, the testing phase. The prototype of the application will be brought to the site which is any branch of PDM. Data will be gathered. Any feedbacks and bugs will be fixed and process will continue until goal is achieved.

Lastly, the operations phase, the application will be gifted to PDM for educational usage.

3.7 User Requirements

R1: The system will be able to perform certain touch sensation that mimics texture.

R2: The system is able to produce force feedback.

R3: The system will be able to test which sensation produces the best response from dyslexic kids.

3.8 System Performance Definition

The target of improvement is the knowledge about dyslexic students before and after using the application.

3.9 Verification Plan

An examination

10 questions will be designed based on various sensations. Dyslexic participants are then instructed to complete all 10 questions. The time taken and results are recorded. Results are tabulated and analyzed.

3.10 Project Scope

The project scope is to develop an educational based computer application with a set of functionalities as the intention of the study is to investigate the application of force-feedback as an alert mechanism encouraging the dyslexia students learning environment.

CHAPTER 4: DATA COLLECTION

4.1 Fact Finding

Interview is a fact-finding technique whereby the system analyst gathers information through face to face interaction. In this research, I have visited a branch of Persatuan Dyslexia Malaysia which is located at USJ 4, Subang Jaya, Selangor to gather requirements. A list of closed ended and open-ended questions is designed to gather requirements.

Figure 4.1

Through observation, i have gathered requirements. Students that are from Persatuan Dyslexia Malaysia tend to get more excited when teaching involve using objects. A noticeable rise in interest and excitement was displayed by the students.

Figure 4.2

On the other hand, when objects are not used. Students lose interest easily and sometimes run around the classroom, stand up or do unnecessary movements in order to distract themselves from the lesson.

Figure 4.3

Items and objects are used to conduct lessons. In this example, a colorful set of blocks are used to teach math (subtraction and addition). Story books are used to improve the students reading skills, touch sensation is not used and implemented while teaching students how to read.

Figure 4.4

The students have their classes 5 days a week and they have 4 different subjects which is Bahasa, English, Math and Art. Once they complete their final examination which is conducted once every 6 months, they are allowed to graduate from the school and proceed to elementary school. If the students did not pass the exam, he or she has to stay for another semester.

……..

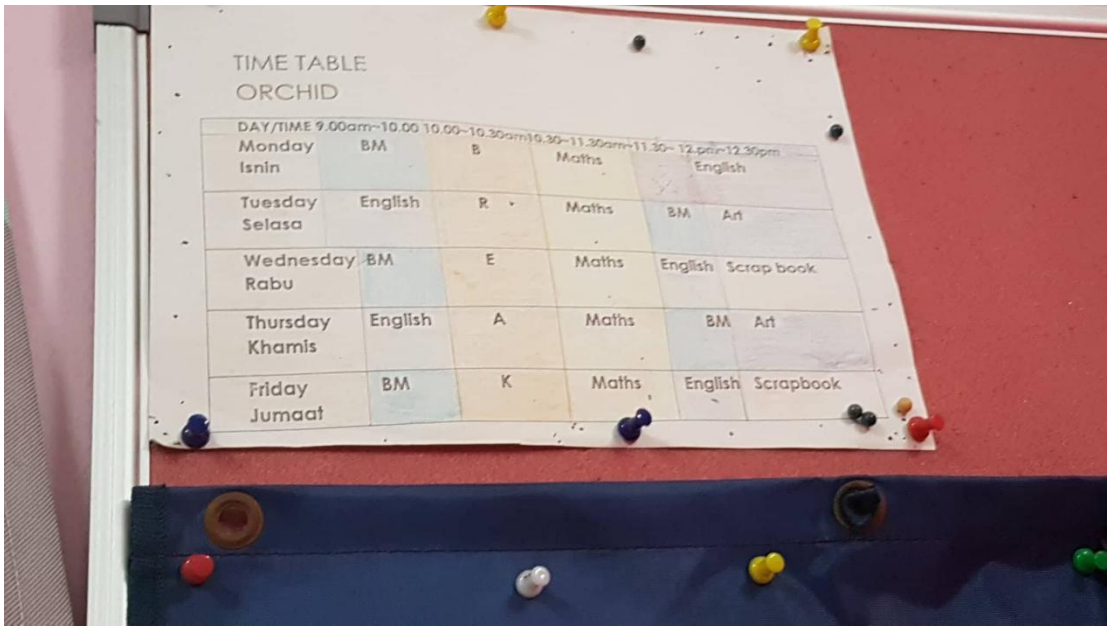

Figure 4.5

4.2 Interview Data

Summarized Criteria target users.

Description	Criteria
Basic communication skills	needed
Age	3~12
Learning disability	Dyslexic
Physical disability	have functional arms and hands, students that are blind are more acceptable.

Table 4.1

The criteria of participants are categorized into 4 items. Participants for this research must be able to understand and have basic communication skills for testing. This is to ensure that they understand instructions given by the application during testing,

The software is designed for dyslexic children, hence students that are diagnosed with dyslexic that are age 3~12 are chosen as participants for this research.

Participants must not physical disability such missing both limbs and arms, the Phantom Omni requires an arm to function for its desired purpose. Blindness is acceptable as oral test can be conducted on them.

Any participants that meet 4 of the criteria is suitable to use this application.2.2.2 Interview Respondents

Respondents	Knowledge and skills
Chairman	i. Most experienced and well knowledgeable among the 3 instructors ii. Head of USJ 4 Persatuan Dyslexia Malaysia iii. Coordinator iv. Head instructor
Instructor 1	i. Has very high knowledge about dyslexic kids. ii. Almost 10 years teaching experience. iii. Has a good ability to develop relationship with the students.
Instructor 2	i. Has clear Objectives in lessons ii. Passion for children and teaching iii. Has an engaging type of teaching-style.

Table 4.2

Through close ended questions, I have found out that the current system does not use computer in the teaching process. Internet is not available. All of the teachers think that a computer software will aid them in teaching. They agreed that they face difficulty in teaching the students. Computers are available, but internet is not.

4.3 Summary of the interview findings

Rule	Issues and Views
Chairman	Headquarter of Persatuan Dyselxia Malaysia does not introduce any new methods of teaching the students, it has been that way ever since. Any research done by students are always only implemented in the headquarter located in Ampang. Different Branches have different teaching methods, hence permission to visit 3 branches of Persatuan Dyslexia Malaysia has been requested and been accepted which is Penang, Ampang and USJ 4 branch. During testing, a site visit on the 4 branches will be conducted. Students here have difficulty in learning alphabets especially letters that can be mirrored, for example the letter ‘p’ and ‘q’ , students fail to understand and full grasp these kind of Alphabets are hard to teach as dyslexic students cant distinguish between mirrored letters such as p and q. Therefore I designed and will create a game that teaches alphabet.
Instructor	Dyslexic students are difficult to teach as they tend to lose focus easily. This is because they find it challenging to understand symbols and words, hence the students will lose their interest in the subject.

	The software will be designed like a game to attract the interest of the students. This is to ensure the students keep their focus on the application during research. Bahasa is easier to teach compared to English as Bahasa uses the ‘suku-kata’ concept while English have silent words like ‘phone’ and ‘knee’. Students have difficulty understanding phonic sounds. Hence, phonic sounds will be implemented in the game English, Bahasa Math and Art are the subjects taught in the school. A language, math and art game will be designed and created for each subject Subtraction that involves 11~19 that needs to ‘borrow value from tens’ is especially difficult to teach to the students. We hope you’re able to help. Students find it difficult to borrow value, in the math-games. A 2D game will be created specifically for this purpose. Phonic sounds of alphabets might help to improve the application. Phonic sounds is the ‘suku-kata’ of English language. The game will have phonic sounds.
Students	Unfortunately, permission was not given to directly interview the students. But through observation, dyslexic students potraited few of the habits. II. They get excited when they play with objects, for example blocks, legos, strings and knots.

	III. They tend to play with colorful objects compared to dull objects. IV. Pictures and drawings are a distraction. The instructor requested a dull interface as cartoons and pictures on the user interface will distract them from completing a specific task given.

Table 4.3

Through observation, the students have used a variety number of objects to aid their learning process. A few items are picked to further study and research which texture will stimulate a learning enhancement on the students.

Objects	Sensation
Lego	Rough surface
Colorful blocks	Smooth surface
Wooden table	Wood
Glue	Magnetic / sticky

Table 4.4

CHAPTER 5: TESTING AND RESULTS

5,1 Testing Process

Figure 5.1

A visit to Ace Kids Dyslexia Centre Penang and PDM USJ 4 branch was done to get results.

Figure 5.2

The figure shows dyslexic students from Penang using the Phantom Omni.

Figure 5.3

Figure shows dyslexic students from USJ 4 Persatuan Dyslexia Malaysia.

First off, participants were introduced to the phantom omni. Before the test takes place, a brief guidance and introduction were given to the participants. They are allowed to play and use the Phantom omni for 5 mins. After 5 mins, they are required to answer a set of 10 questions. The questions are designed based on various sensations.

5.2 Explicit User Experience Assessment (UXA)

User's emotions and reactions were observed and recorded using **thinking aloud protocol**. throughout the testing sessions in both venues (Penang and USJ). As participant were in a younger age group, observing facial expressions is the key to evaluate their emotions.

Student no	Emotions and Actions
1	At first, the student was curious and played around with the sensations for a period of time. He was unsure and answered the questions uncertainly without confidence. During the 4th and 9th question the student was quick and confident in his answer, as well as excited and described the sensation as "ping pong".
2	Student was highly cooperative when he discovered prize is awarded at the end of the quiz. When he did a mistake, he insisted to redo the question until he got the correct answer.
3	Student wasn't really interested in the game. She was fairly confused on what is happening. She does not have good language skill and communication was difficult. After answering answer questions incorrectly, she felt down, defeated and gives up.
4	Student was very excited when feeling constant force sensation. She made a tune like "boink boink" when feeling the texture. She was very cooperative and well behaved. She needed assistance on all of the questions.
5	Student is very talented and smart, he understood the game in a short period of time. He was unsatisfied with his 1 error and requested to play the game again. He got perfect score after that.

6	Student is shy and quiet. He does not know English or mandarin. Hence, we communicated in Bahasa Malaysia. He communicated by knotting his head for approval and shaking his head for disapproval.
7	Student said “It was very easy” when he completed the task. He was not hesitant when answering the questions. He did not retry the sensations to double confirm the answer. He was very confident about his selections.
8	Student is not able to communicate fluently in English, hence we communicated in Mandarin. When unsure, she picks Viscosity as the answer as viscosity as the same color tone as the question. She required assistance for every
9	At first, student did not understand the question. He thought that the question was to match the colors and not the sensation. After some explaining, he was able to answer the questions with ease.
10	Student was very confident when answering questions, he does not doubt his answers and is a quick learner.
11	Student was very confident when answering questions, he took longer time in answering questions that provide a viscosity sensation.
12	At first, student was confused by the question. After that he was very confident in his answers especially question 9.
13	Excited and happy during constant force, this student uses elimination process to get his answer.
14	Students is shy and very quiet, he lacks communication skills. A glimpse of excitement is shown when playing with constant force.

15	Students describes Friction as shaky, he was confident in his answers and is excited during constant force.
16	Student was very quick and accurate on constant force and vibration, he was very confident and did not hesitate nor doubt his answers.
17	Student was emotionless and lack basic communication skill, this student was excited about the quiz but he did not did well.

Table 5.1

Through observations, a majority of students tend to get excited when playing with the sensation “constant force”. They describe the sensation as “bouncy”, “jumpy”, ”boink-boink” and “ping-pong”. They did not describe any other sensations and does not seem to get excited over them.

Besides that, participants were very quick and confident of their answers after they understand the questions Participants show great confidence and did not doubt their answers. Amazingly, one participant used the elimination process as his tool to find the answers.

5.2 Participant Background and scores

Participant no	Age	Sex	Score	Average time taken per questions
1	8	M	8	34.5s
2	7	M	7	42.5s
3	5	F	5	59.1s
4	6	F	7	38.4s
5	10	M	9	37.1s

6	5	M	5	37.1s
7	11	M	9	24.5s
8	5	F	6	46.6s
9	10	M	9	39.3s
10	9	M	7	28.5s
11	11	M	7	29.3s
12	8	M	8	28.9s
13	8	M	8	37.8s
14	8	M	8	24.4s
15	8	M	9	41.6s
16	8	M	6	23.6s
17	7	M	2	36.8s

Table 5.2

Total: 3 Female, 14 Male participants.

Average Score = Total Score / Participant no

= (8+7+5+7+9+5+9+6+9+7+7+8+8+8+9+6+2)/17

=7.06

Average Age = Total age / Participant no

= (8+7+5+6+10+5+11+5+10+9+11+8+8+8+8+8+7)/17

= 7.88

Mean time taken =

(34.5+42.5+59.1+38.4+37.1+37.1+24.5+46.6+39.3+28.5+29.3+28.9+37.8+24.4+41.6+23.6+36.8)/17

=35.88s per student per question

5.3 Buffer time Calculation

Buffer Time Calculations (In Seconds)

Buffer time = (35%*Mean Time Taken)+ Mean Time Taken

Buffer Time =(35%*35.88s)+35.88s

=48.438s

5.4 Tabulation of results

Score Table (Updated)

Question	Correct Count	Incorrect Count
1	11	12
2	11	12
3	15	8
4	22	1
5	22	1
6	11	12
7	14	9
8	13	10
9	23	0
10	19	4

Table 5.3

Average score per student: 7

Average time taken per question per student:35.88s

Sensation Score Table (updated)

Sensation	Correct Count	Incorrect Count
Spring	22	24
Viscosity	25	21
Friction	28	18
Constant Force	45	1

Vibration	41	5

Table 5.4

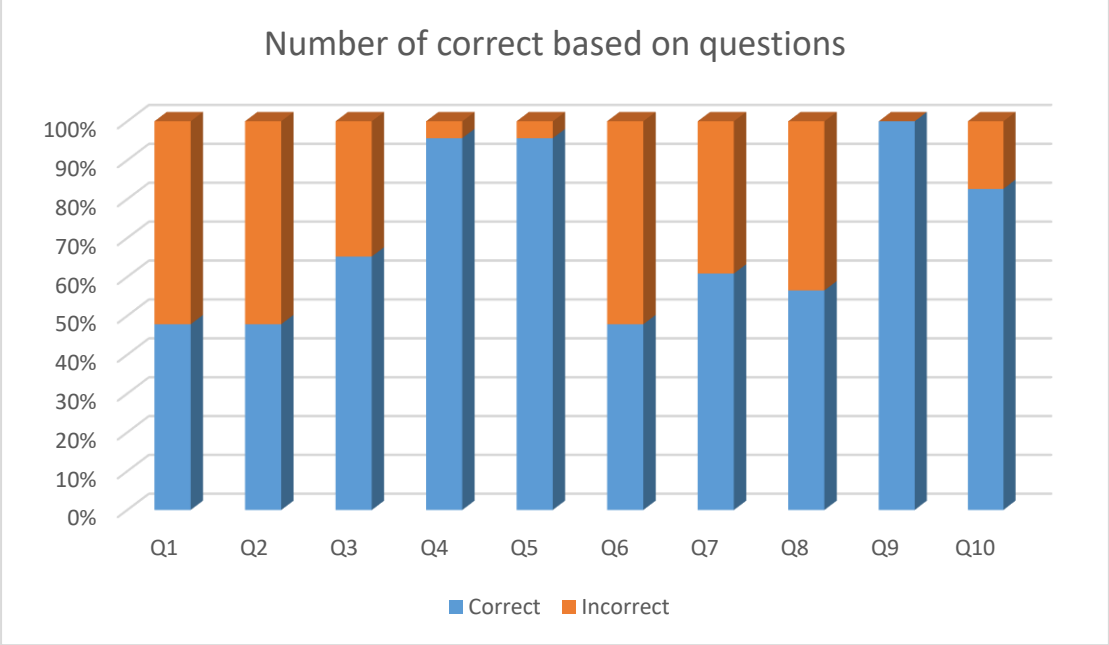

Figure 5.4 (updated)

Figure xx shows the number of correctly answered based on questions numbers. The scores can be categorized into 3 groups, Class A above 80%, Class B 60~79% and Class C below 60%. The bar graph shows that Q4, Q5, Q9 and Q10 falls in class A. Q3, Q7 and Q8 falls in class B and Q1, Q2 and Q6 falls under Class C.

With this knowledge in mind, we can sort the questions by sensations to gain a better understanding. 121

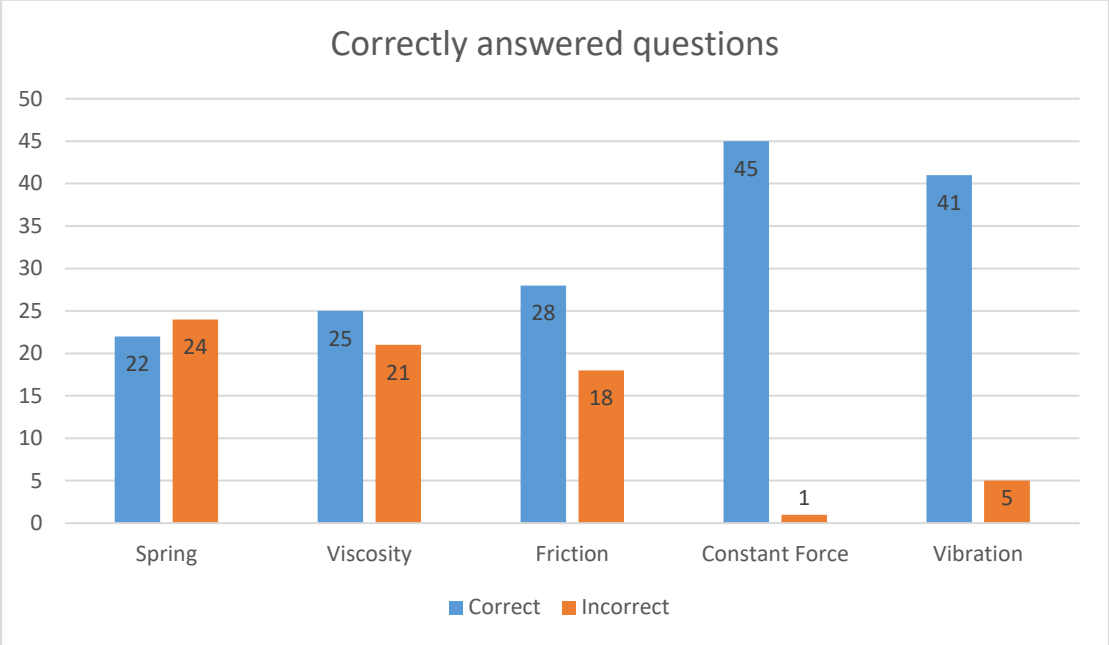

Figure 5.5 (updated)

Figure xx shows the correctly answered questions based on sensations, Constant force peaks and shows the highest results at 33 correctly answered questions and 1 incorrectly answered. Meanwhile Vibrations falls second by having 1 less correctly answered questions and an additional 1 incorrectly answered question.

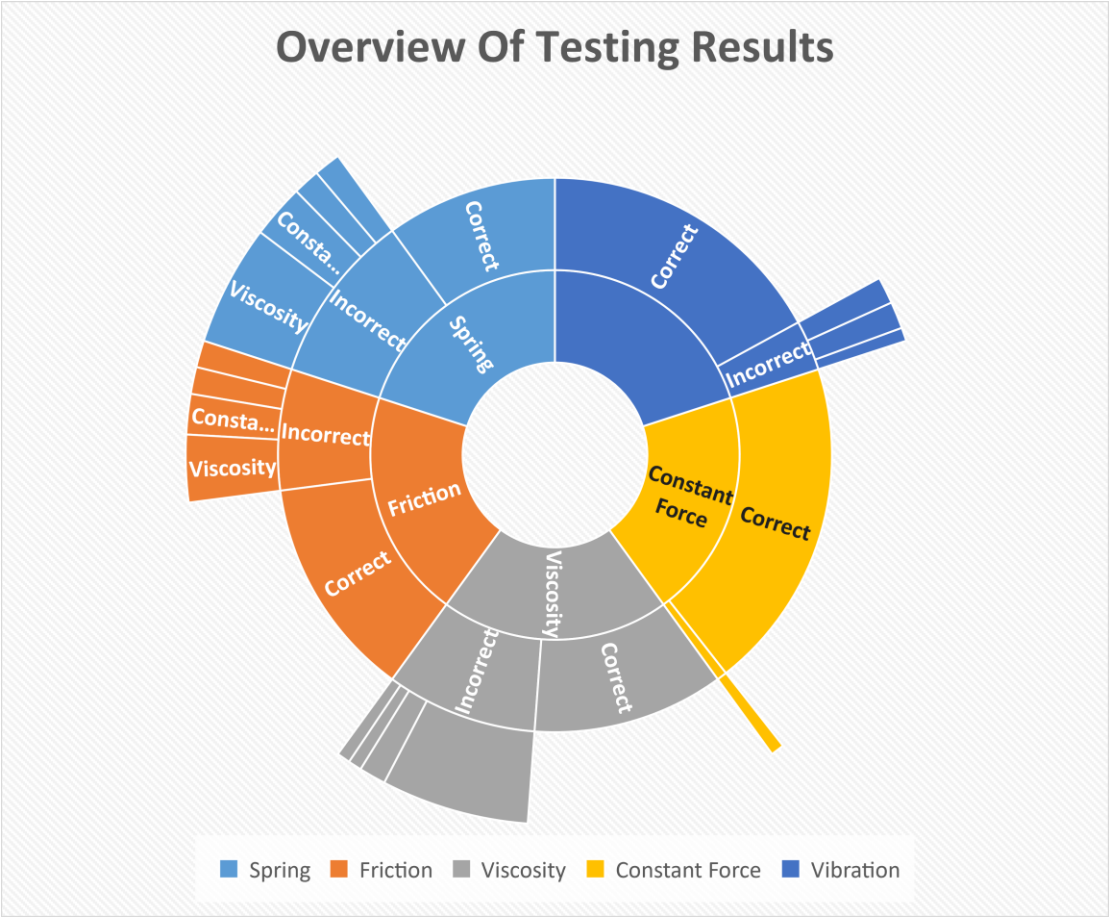

Figure 5.6

Sensation	Correct/Incorrect	Answered	Score
Spring	Correct		17
	Incorrect	Friction	2
	Incorrect	Vibration	2
	Incorrect	Viscosity	9
	Incorrect	Constant Force	4
Friction	Correct		22
	Incorrect	Spring	2
	Incorrect	Vibration	2

	Incorrect	Viscosity	5
	Incorrect	Constant Force	3
Viscosity	Correct		19
	Incorrect	Spring	1
	Incorrect	Vibration	11
	Incorrect	Constant Force	1
	Incorrect	Friction	2
Constant Force	Correct		33
	Incorrect	Spring	0
	Incorrect	Vibration	1
	Incorrect	Viscosity	0
	Incorrect	Friction	0
Vibration	Correct		29
	Incorrect	Spring	2
	Incorrect	Viscosity	0
	Incorrect	Friction	1
	Incorrect	Constant Force	2

Table 5.5

5.5 Efficiency, Effectiveness and Satisfaction calculation

Test Results Measuring the Efficiency Component for Preliminary Study

Description of Criteria / Participants			Total	Average by Criteria
Criteria 1: User able to keep the number of mistakes at minimal rate. (Yes -> 1~3 error , Partial 4~6 error, No, >7 error				
0%	50%	100%		
1	4	12	1400%	82.35%
Criteria 2: User Able to complete each task within the reasonable period of time. Yes <= Mean time, Partial > mean time, < meantime + buffer time, no>buffer time				
0%	50%	100%		
2	9	7	1150%	67.65%
Total of all criteria				150%
Overall Average (Total of all Criteria/ Number of Criteria)				75%

Table 5.6

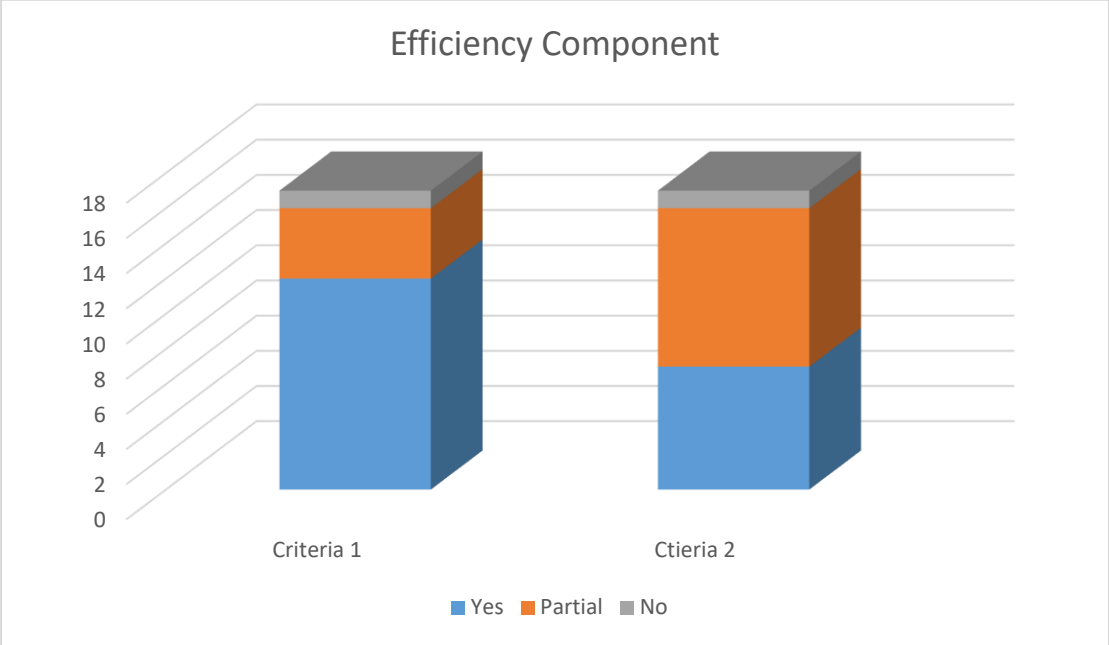

Figure 5.7

Criteria 1 scored an average by criteria of 35.29%, the table shows that no participant was able to get 0 errors. 12 participants partially had minimal mistakes and 5 participants that has more than 3 errors.

Meanwhile, Criteria 2 shows that 7 participants were able to complete task quicker than the mean time, 9 participants were able to complete the task in the range of mean time and meantime + buffer time, and 1 participant that took more than the buffer time to complete the task.

Test Results Measuring the Effectiveness Component

Description of Criteria / Participants		Total	Average by Criteria
Criteria 1: User able to understand on how to complete the given task			
0	100%		

0	17		1700%	100%
Criteria 2: User Able to complete the entire task successfully				
0	100			
0	17		1700%	100%
Criteria 3: User able to complete the task without any guidance Yes -> 0 assistance, Partial-> 2~3 assistance, No-> >3 assistance				
0%	50%	100%		
7	8	2	600%	35.29%
Total of all criteria				235.29
Overall Average (Total of all Criteria/ Number of Criteria)				78.43

Table 5.6

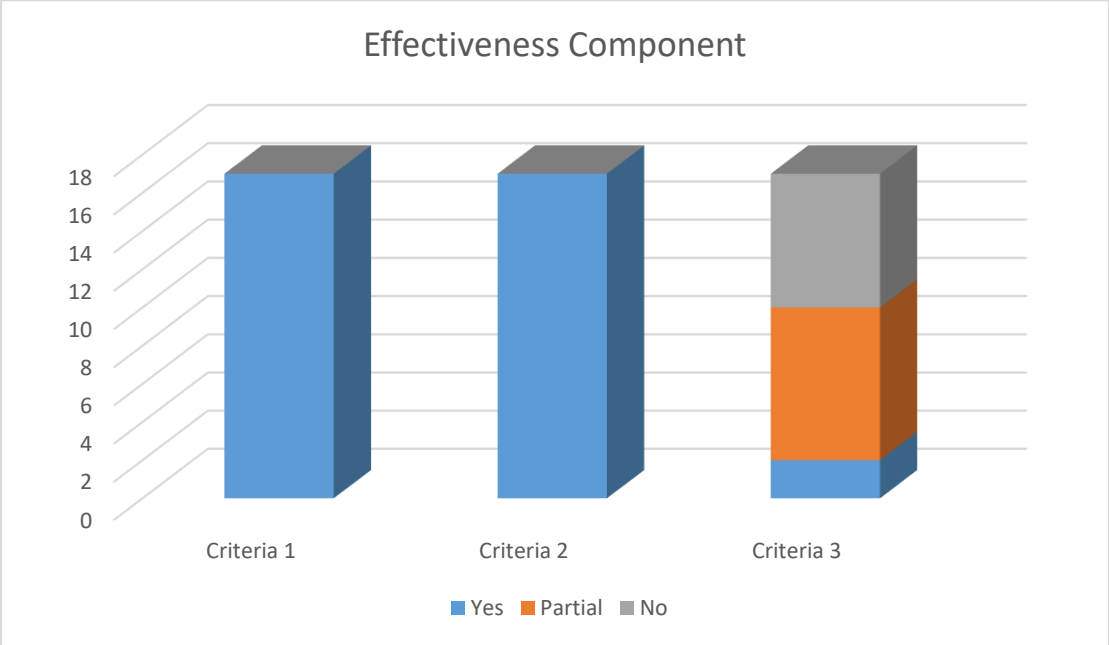

Figure 5.8

The total of all criteria sums up to 235.29% and overall average for all criteria for this test is 78.43%.

Participants were able to score perfectly on criteria 1 and criteria 2, they were able to understand on how to complete the task and they are able to complete the entire task successfully.

On the other hand, 8 participants needed assistance partially. 2 participants did not need any assistance and 7 participants required a lot of assistance.

Test Results Measuring the Satisfaction Component

Description of Criteria / Participants		Total	Average by Criteria
Criteria 1: The game was enjoyable			
0%	100%		
1	16	1600%	94.11%
Criteria 2: The game was not difficult			
0%	100%		
3	14	1400%	82.35%
Criteria 3: Lessons would be more enjoyable with the device			
0	100%		
0	16	1600%	94.11%

Total of all criteria	270.57
Overall Average (Total of all Criteria/ Number of Criteria)	90.19%

Table 5.8

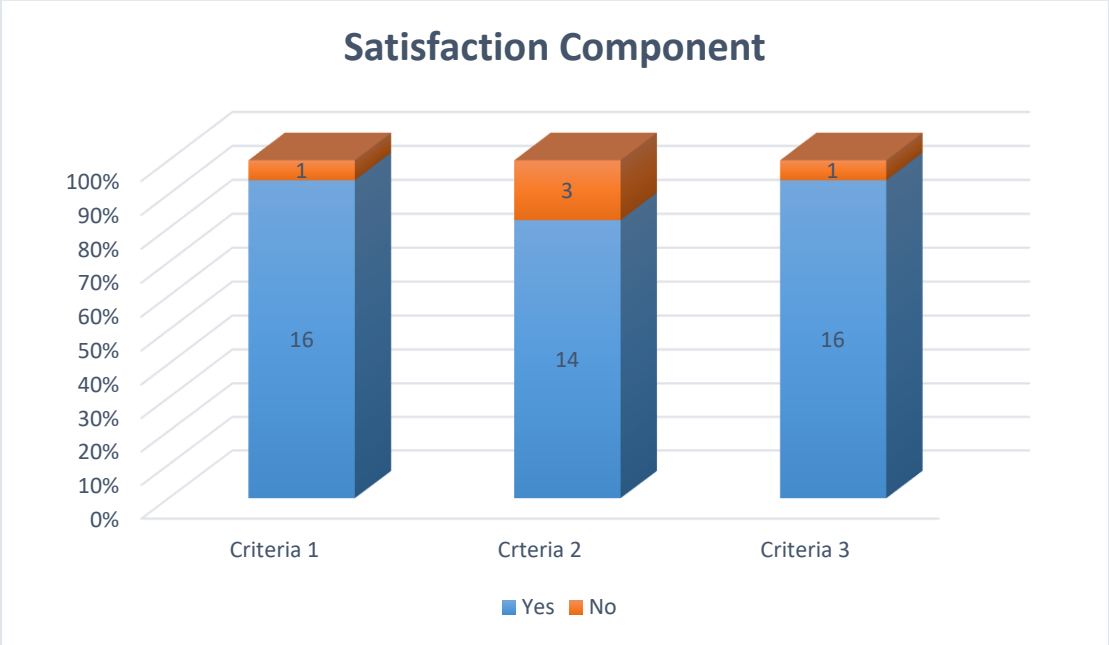

Figure 5.9

The table and chart show the Test Results Measuring the Satisfaction Component.

Majority of the participants was satisfied with the system. 16 out of 17 participants feel that the game was enjoyable. Meanwhile 14 out of 17 participants agreed that the game was not that difficult. Lastly,16 of 17 participants would enjoy their lessons better if the device is used in class. Overall average satisfaction is 90.19%.

Measuring the Usability of the current Design Computer Application

Usability (%) = (Efficiency + Effectiveness + Satisfaction) / Number of measured components.

Usability (%) = (51.47%+90.19%+78.43%)/3

= 73.36

CHAPTER 6: CONCLUSION

6.1 Conclusion

In conclusion, Persatuan Dyslexia Malaysia does not use force feedback or haptic touch-based teaching. Educational applications that are available does not incorporate force feedback. Furthermore, these applications are not designed for students that suffer from dyslexia. To overcome this problem, we must first address what kind of touch sensation is most suitable for the dyslexic. This research aims to accurately determine what type of touch sensation is the most suitable and stimulate the best response on dyslexic students.

After analyzing the data, we can conclude that constant force is the most suitable sensation to be used and implemented into software for dyslexic students. Meanwhile, vibration comes second place after constant force,

6.1 Contribution

Our research was able to determine that force-feedback is a suitable as an element to be implemented in the teaching format for dyslexic students.

Previous research suggested that haptic touch is beneficial for the students. Hence, this research has proven that constant force and vibration is the best sensation or force-feedback to be used for dyslexic students.

6.2 Future Work

An educational based app can be created with this knowledge. We can use constant force and vibration sensation as an element to create a program that smoothen the learning process of dyslexic kids on alphabets and symbols.

Besides that, further testing on dyslexic kids shall be done as the results between constant force and vibration is close. More participants are required to further study and to be observed to get a credible result.

Apendices

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Interview questions

Close ended questions

1. Q. .Does computer involved in any teaching process ?

2. Q. In your opinion do you think a computer software will be able to aid in the learning process ?

4.Q Are the teaching methods the same among all the branches?

5.Q. Is internet available in this area ?

Open Ended questions.

Question and answer	Comments
What do you find difficulty in teaching ? Answer: Alphabets , students here have difficulty in learning alphabets especially letters that can be mirrored , for example the letter ‘p’ and ‘q’ , students fail to understand and full grasp these kind of letters.	Alphabets are hard to teach as dyslexic students cant distinguish between mirrored letters such as p and q. Therefore I designed and will create a game that teaches alphabet.
Which is harder to teach , lower case or upper case ? Answer: Lower case , for some reason , students are able to grasp upper case letters easily , but most fail to properly learn lower case letters.	During the past project, only capital letters are used in the game. My game will implement lower case letters
What language is harder to teach , Bahasa or English ? Answer :Bahasa is easier to teach compared to English as Bahasa uses the ‘suku-kata’ concept while English have silent words like ‘phone’ and ‘knee’.	Students have difficulty understanding phonic sounds. Hence , phonic sounds will be implemented in the game.
What subjects do you teach ? English , Bahasa Maths and Art.	A language , maths and art game will be designed and created for each subject.

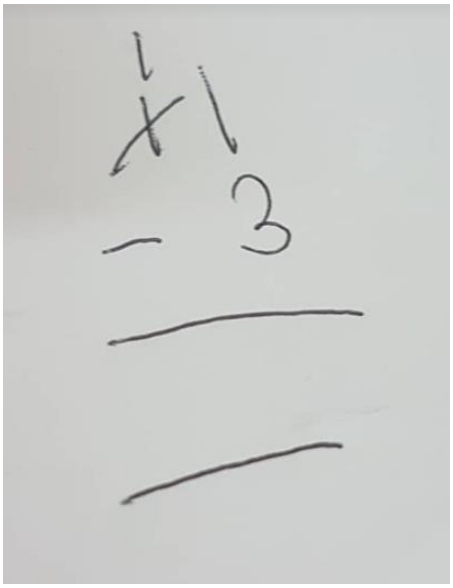
Do students have difficulty in learning maths ? A. Yes , subtraction that involves 11~19 that needs to ‘ borrow value from tens’ is especially difficult to teach to the students. We hope you’re able to help. 	Students find it difficulty to borrow value , in the maths game . A 2D game will be created specifically for this purpose.
Is there any other suggestions that you would like to implement in this application? A. Phonic sounds of alphabets might help to improve the application. Phonic sounds is like the ‘suku-kata’ of English language.	The game will have phonic sounds.

Table 5.1

Student 1

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Force)	155s	Yes
2	Viscosity	Correct	56s	Yes
3	Friction	Correct	53s	No
4	Constant Force	Correct	2s	No
5	Vibration	Correct	14s	No
6	Spring	Incorrect (Friction)	12s	No
7	Viscosity	Correct	21s	No
8	Friction	Correct	23s	No
9	Constant Force	Correct	8s	No
10	Vibration	Correct	1s	No

Comments: At first, the student was curious and played around with the sensations for a period of time. He was unsure and answered the questions uncertainly without confidence. During the 4^{th} and 9^{th} question the student was quick and confident in his answer, as well as excited and described the sensation as “ping pong”.

Score: 8 /10

Average Time taken per question: 34.5s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 2

Age: 7

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Force)	143s	Yes
2	Viscosity	Incorrect (Vibration)	61s	Yes
3	Friction	Correct	28s	Yes
4	Constant Force	Correct	16s	Yes
5	Vibration	Correct	15s	Yes
6	Spring	Correct	17s	Yes
7	Viscosity	Correct	56s	No
8	Friction	Correct	11s	No
9	Constant Force	Correct	22s	No
10	Vibration	Incorrect (Friction)	56s	No

Comments: Student was highly cooperative when he discovered prize is awarded at the end of the quiz. When he did a mistake, he insisted to redo the question until he got the correct answer.

Score: 7 /10

Average Time taken per question: 42.5s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 3

Age: 5

Gender: Female

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Viscosity)	144s	Yes
2	Viscosity	Correct	76s	Yes
3	Friction	Incorrect (Viscosity)	191s	Yes
4	Constant Force	Correct	45s	Yes
5	Vibration	Correct	23s	Yes
6	Spring	Incorrect (Force)	13s	Yes
7	Viscosity	Correct	27s	Yes
8	Friction	Incorrect (Force)	33s	Yes
9	Constant Force	Correct	16s	Yes
10	Vibration	Incorrect (Force)	23s	Yes

Comments: Student wasn't really interested in the game. She was fairly confused on what is happening. She does not have good language skill and communication was difficult. After answering answer questions incorrectly, she felt down, defeated and gives up.

Score: 5/10

Average Time taken per question: 59.1s

Interview Questions

1. Was the game enjoyable? (No)

2. Was the game difficult? (Yes)

3. Would your lessons be more enjoyable if this device is used during lessons? (No)

Student 4

Age: 6

Gender: Female

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Viscosity)	124s	Yes
2	Viscosity	Incorrect (Vibration)	43s	Yes
3	Friction	Correct	19s	Yes
4	Constant Force	Correct	7s	Yes
5	Vibration	Correct	16s	Yes
6	Spring	Correct	65s	Yes
7	Viscosity	Correct	15s	Yes
8	Friction	Incorrect (Spring)	25s	Yes
9	Constant Force	Correct	31s	Yes
10	Vibration	Correct	39s	Yes

Comments: Student was very excited when feeling constant force sensation. She made a tune like “boink boink” when feeling the texture. She was very cooperative and well behaved. She needed assistance on all of the questions.

Score: 7/10

Average Time taken per question: 38.4s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 5

Age: 10

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	51s	No
2	Viscosity	Incorrect (Vibration)	10s	No
3	Friction	Correct	6s	No
4	Constant Force	Correct	7s	No
5	Vibration	Correct	7s	No
6	Spring	Correct	34s	No
7	Viscosity	Correct	145s	No
8	Friction	Correct	85s	No
9	Constant Force	Correct	12s	No
10	Vibration	Correct	14s	No

Comments: Student is very talented and smart, he understood the game in a short period of time. He was unsatisfied with his 1 error and requested to play the game again. He got perfect score after that.

Score: 9/10

Average Time taken per question: 37.1s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 6

Age: 5

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	51s	Yes
2	Viscosity	Incorrect (Vibration)	42s	Yes
3	Friction	Incorrect (Vibration)	40s	No
4	Constant Force	Correct	19s	No
5	Vibration	Correct	18s	No
6	Spring	Incorrect (Viscosity)	42s	No
7	Viscosity	Incorrect (Vibration)	34s	No
8	Friction	Correct	18s	No
9	Constant Force	Correct	8s	No
10	Vibration	Incorrect (Spring)	28s	No

Comments: Student is shy and quiet. He does not know English or mandarin. Hence we communicated in Bahasa Malaysia. He communicated by knotting his head for approval and shaking his head for disapproval.

Score: 5/10

Average Time taken per question: 37.1s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (Yes)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 7

Age: 11

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	90s	No
2	Viscosity	Correct	13s	No
3	Friction	Correct	39s	No
4	Constant Force	Correct	1s	No
5	Vibration	Correct	28s	No
6	Spring	Correct	17s	No
7	Viscosity	Correct	7s	No
8	Friction	Incorrect (Spring)	30s	No
9	Constant Force	Correct	1s	No
10	Vibration	Correct	19s	No

Comments: Student said “It was very easy” when he completed the task. He was not hesitant when answering the questions. He did not retry the sensations to double confirm the answer. He was very confident about his selections.

Score: 9/10

Average Time taken per question: 24.5s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 8

Age: 5

Gender: Female

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Viscosity)	108s	Yes
2	Viscosity	Correct	56s	Yes
3	Friction	Incorrect (Viscosity)	42s	Yes
4	Constant Force	Correct	30s	Yes
5	Vibration	Correct	35s	Yes
6	Spring	Incorrect (Viscosity)	26s	Yes
7	Viscosity	Correct	50s	Yes
8	Friction	Incorrect (Viscosity)	48s	Yes
9	Constant Force	Correct	40s	Yes
10	Vibration	Correct	31s	Yes

Comments: Student is not able to communicate fluently in English, hence we communicated in Mandarin. When unsure, she picks Viscosity as the answer as viscosity as the same color tone as the question. She required assistance for every question.

Score: 6/10

Average Time taken per question: 46.6s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (Yes)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 9

Age: 10

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Viscosity)	92s	Yes
2	Viscosity	Correct	48s	No
3	Friction	Correct	62s	No
4	Constant Force	Correct	20s	No
5	Vibration	Correct	30s	No
6	Spring	Correct	41s	No
7	Viscosity	Correct	46s	No
8	Friction	Correct	32s	No
9	Constant Force	Correct	10s	No
10	Vibration	Correct	12s	No

Comments: At first, student did not understand the question. He thought that the question was to match the colors and not the sensation. After some explaining, he was able to answer the questions with ease.

Score: 9/10

Average Time taken per question: 39.3s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 10

Age: 9

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	21s	Yes
2	Viscosity	Correct	21s	No
3	Friction	Correct	37s	No
4	Constant Force	Correct	28s	No
5	Vibration	Correct	20s	No
6	Spring	Incorrect (Viscosity)	30s	No
7	Viscosity	Correct	29s	No
8	Friction	Incorrect (Viscosity)	36s	No
9	Constant Force	Correct	28s	No
10	Vibration	Incorrect (Force)	35s	No

Comments: Student was very confident when answering questions , he does not doubt his answers and is a quick learner.

Score: 7/10

Average Time taken per question: 28.5s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 11

Age: 11

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Vibration)	38s	Yes
2	Viscosity	Correct	21s	No
3	Friction	Incorrect (Viscosity)	40s	No
4	Constant Force	Correct	29s	No
5	Vibration	Correct	24s	No
6	Spring	Correct	21s	No
7	Viscosity	Incorrect (Vibration)	50s	No
8	Friction	Correct	20s	No
9	Constant Force	Correct	26s	No
10	Vibration	Correct	24s	No

Comments: Student was very confident when answering questions, he took longer time in answering questions that provide a viscosity sensation.

Score: 7/10

Average Time taken per question: 29.3s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 12

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	58s	Yes
2	Viscosity	Incorrect (Vibration)	21s	No
3	Friction	Correct	27s	No
4	Constant Force	Correct	28s	No
5	Vibration	Correct	42s	No
6	Spring	Correct	32s	No
7	Viscosity	Incorrect (Vibration)	91s	No
8	Friction	Correct	51s	No
9	Constant Force	Correct	8s	No
10	Vibration	Correct	21s	No

Comments: At first, student was confused by the question. After that he was very confident in his answers especially question 9.

Score: 8/10

Average Time taken per question: 28.9s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 13

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	28s	Yes
2	Viscosity	Incorrect (Vibration)	10s	Yes
3	Friction	Correct	10s	No
4	Constant Force	Correct	12s	No
5	Vibration	Correct	62s	No
6	Spring	Correct	72s	No
7	Viscosity	Incorrect (Vibration)	82s	No
8	Friction	Correct	52s	No
9	Constant Force	Correct	60s	No
10	Vibration	Correct	12s	No

Comments: Excited and happy during constant force , this student uses elimination process to get his answer.

Score: 8/10

Average Time taken per question: 37.8s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 14

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	32s	Yes
2	Viscosity	Correct	18s	Yes
3	Friction	Incorrect (Vibration)	10s	Yes
4	Constant Force	Correct	18s	Yes
5	Vibration	Correct	21s	Yes
6	Spring	Incorrect (Vibration)	15s	Yes
7	Viscosity	Correct	20s	Yes
8	Friction	Correct	51s	Yes
9	Constant Force	Correct	41s	No
10	Vibration	Correct	18s	No

Comments: Students is shy and very quiet, he lacks communication skills. A glimpse of excitement is shown when playing with constant force.

Score: 8/10

Average Time taken per question: 24.4s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 15

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Correct	61s	Yes
2	Viscosity	Incorrect (Spring)	72s	Yes
3	Friction	Correct	18s	Yes
4	Constant Force	Correct	21s	Yes
5	Vibration	Correct	52s	No
6	Spring	Correct	58s	No
7	Viscosity	Correct	40s	No
8	Friction	Correct	38s	No
9	Constant Force	Correct	16s	No
10	Vibration	Correct	40s	No

Comments: Students describes Friction as shaky, he was confident in his answers and is excited during constant force.

Score: 9/10

Average Time taken per question: 41.6

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 16

Age: 8

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Constant Force)	68s	Yes
2	Viscosity	Incorrect (Constant Force)	27s	Yes
3	Friction	Correct	11s	Yes
4	Constant Force	Correct	8s	No
5	Vibration	Correct	3s	No
6	Spring	Incorrect (Friction)	31s	No
7	Viscosity	Incorrect (Vibration)	28s	No
8	Friction	Correct	28s	No
9	Constant Force	Correct	7s	No
10	Vibration	Correct	25s	No

Comments: Student was very quick and accurate on constant force and vibration, he was very confident and did not hesitate nor doubt his answers.

Score: 6/10

Average Time taken per question: 23.6s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Student 17

Age: 7

Gender: Male

Question No	Sensation	Results (Correct/Incorrect)	Time Taken	Assistance
1	Spring	Incorrect (Viscosity)	38s	Yes
2	Viscosity	Incorrect (Friction)	42s	Yes
3	Friction	Incorrect (Constant Force)	41s	Yes
4	Constant Force	Incorrect (Vibration)	46s	Yes
5	Vibration	Incorrect (Spring)	18s	Yes
6	Spring	Incorrect (Viscosity)	43s	Yes
7	Viscosity	Incorrect (Friction)	38s	Yes
8	Friction	Incorrect (Force)	38s	Yes
9	Constant Force	Correct	32s	No
10	Vibration	Correct	32s	No

Comments: Student was emotionless and lack basic communication skill, this student was excited about the quiz but he did not did well.

Score: 2/10

Average Time taken per question: 36.8s

Interview Questions

1. Was the game enjoyable? (Yes)

2. Was the game difficult? (No)

3. Would your lessons be more enjoyable if this device is used during lessons? (Yes)

Scripts

Haptic Motion

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

using UnityEngine.UI;

using UnityEngine.EventSystems;


public class HapticMouse : MonoBehaviour {



    /*

     *  This is a very simple example of how to use the haptic device as a cursor.

     *  I simply casts a ray to find all UI elements overlapping the stylus tip, and sends mouse-down events. Very basic.

     */


    /* If you need a UI that fits more smoothly with the scene, you may get more elegant results if you put the UI canvas in

     *  the scene, attached to a 'touchable' plane, and then trigger the UI events when the stylus 'touches' it.  That will involve

     *  a little math, but it shouldn't be too bad. And it may be worth it to give the illusion of interacting with an imaginary
```

```
     *    touch screen.
     */


    private   HapticPlugin Haptic = null;
    public Camera camera = null;
    public Image cursor = null;


    // Use this for initialization
    void Start ()
    {
        // find the Haptic Device
        Haptic = gameObject.GetComponent(typeof(HapticPlugin)) as HapticPlugin;
        if (Haptic == null)
            Debug.LogError("HapticMouse script must be attached to the same
object as the HapticPlugin script.");


        // Find the camera
        if (camera == null)
            camera = FindObjectOfType<Camera>();
    }
```

```
    private bool buttonHoldDown = false; //state, so we can determine between a click and a button that's held down since last frame


    void Update ()
    {
        //This is a "click" if we're pressed now, but weren't last frame.
        bool click = false;
        if (buttonHoldDown == false && Haptic.Buttons [0] != 0)
            click = true;
        buttonHoldDown = (Haptic.Buttons [0] != 0);



        //Determine the screen position using the stylus position and the camera matrix transforms.
        Vector3 screenPos = camera.WorldToScreenPoint(Haptic.stylusPositionWorld);


        // In this example, the "cursor" is just a UI element.
        // Moving the system mouse cursor is more dificult, and not really recomended.
        if (cursor != null)
            cursor.rectTransform.position = screenPos;
```

```
        PointerEventData pointerData = new PointerEventData
(EventSystem.current);

        List<RaycastResult> results = new List<RaycastResult> ();


        // Perform a raycast to get a list of all elements under the cursor.

        pointerData.position = screenPos;

        EventSystem.current.RaycastAll(pointerData, results);


        // Now that we've found the things. Let's select them ...

        bool selectedAtLeastOneThing = false;

        foreach(RaycastResult R in results)

        {

            GameObject go = R.gameObject;

            Selectable S = go.GetComponent <Selectable>();

            if (S != null)

            {

                S.Select();

                selectedAtLeastOneThing = true;

            }
```

```
            // If we've found a button, we can click on it.
            Button B = go.GetComponent<Button>();
            if (B != null)
            {
                if (click)
                {
                    B.onClick.Invoke();
                    B.Invoke("OnPointerDown",0.0f);
                }
                if (buttonHoldDown == false)
                {
                    B.Invoke("OnPointerUp",0.0f);
                }
            }

        }

        //If we're not hovering over anything, deselect everything.
        // NOTE : This is pretty crude, and will interfere with anyone trying to operate the UI via keyboard.
        if (selectedAtLeastOneThing == false)
        {
            EventSystem.current.SetSelectedGameObject(null);
```

```
            }

        }



}
```

Texture Scripts

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;



public class TextureDemoScript : MonoBehaviour

{

    public Texture2D FrictionTexture = null;

    // Keep track of the Haptic Devices

    HapticPlugin device = null;

    float luminocity = 0.5f;

    [Header("White Surface")]

    [Range(0.0f, 1.0f)] public float hlStiffness = 0.7f;

    [Range(0.0f, 1.0f)] public float hlDamping = 0.1f;

    [Range(0.0f, 1.0f)] public float hlStaticFriction = 0.2f;

    [Range(0.0f, 1.0f)] public float hlDynamicFriction = 0.3f;

    [Range(0.0f, 1.0f)] public float hlPopThrough = 0.0f;
```

```
[Header("Black Surface")]

[Range(0.0f, 1.0f)] public float hlStiffness2 = 0.7f;

[Range(0.0f, 1.0f)] public float hlDamping2 = 0.1f;

[Range(0.0f, 1.0f)] public float hlStaticFriction2 = 0.7f;

[Range(0.0f, 1.0f)] public float hlDynamicFriction2 = 0.9f;

[Range(0.0f, 1.0f)] public float hlPopThrough2 = 0.0f;



// Use this for initialization

void Start ()

{

    device = (HapticPlugin) Object.FindObjectOfType(typeof(HapticPlugin));

}


// Update is called once per frame

void Update ()

{

    // Find the pointer to the collider that defines the "zone".

    Collider collider = gameObject.GetComponent<Collider>();

    if (collider == null)

    {

        Debug.LogError("This Haptic Surface Demo Effect requires a collider");
```

```
            return;
        }

        if (FrictionTexture == null)
        {
            Debug.LogError("This Haptic Surface Demo Effect requires a texture assigned to it.");
            return;
        }

        Vector3 StylusPos = device.stylusPositionWorld;    //World Coordinates
        Vector3 CP = collider.ClosestPointOnBounds(StylusPos);    //World Coordinates
        float delta = (CP - StylusPos).magnitude;

        if (delta < 1.0f)
        {
            Vector3 direction =    transform.position - CP;
            direction.Normalize();
```

```
// Cast a ray between the stylus and the center of the collider
RaycastHit[] hits = Physics.RaycastAll(CP, direction);

//There may be some false positives in the list, so loop through
//and find the hit on the current collider.
foreach (RaycastHit H in hits)
{
    if (H.collider == collider)
    {
        // This is the correct hit, so retrieve the UV values...
        Vector2 UV = H.textureCoord;

        // Scale the UV to the size of the texture...
        int U = (int)(UV.x * FrictionTexture.width);
        int V = (int)(UV.y * FrictionTexture.height);

        // Retrieve the color of that pixel.
        Color C = FrictionTexture.GetPixel(U, V);
        luminocity = C.grayscale;
        break;
    }
```

```
                }


                // Assign the haptic material setttings so that they transition
proportionatly
                // between the two values based on the luminocity of the texel.
                float Value = luminocity;
                float inVal = 1.0f-Value;


                HapticPlugin.shape_settings(gameObject.GetInstanceID(),
                    hlStiffness * Value + hlStiffness2 * inVal,
                    hlDamping * Value + hlDamping2 * inVal,
                    hlStaticFriction * Value + hlStaticFriction2 * inVal,
                    hlDynamicFriction * Value + hlDynamicFriction2 * inVal,
                    hlPopThrough * Value + hlPopThrough2 * inVal);




            }




    }
}
```

Vibration Scripts

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;


public class VibrationDemoScript : MonoBehaviour {


    public HapticPlugin HapticDevice = null;

    private bool vibrationOn;

    private int FXID = -1;


    void Start ()

    {

        vibrationOn = false;

        if (HapticDevice == null)

            HapticDevice =
(HapticPlugin)FindObjectOfType(typeof(HapticPlugin));


        if( HapticDevice /* STILL */ == null )

            Debug.LogError("This script requires that Haptic Device be assigned.");

    }


    void TurnEffectOn()
```

```
    {
        if (HapticDevice == null) return;          //If there is no device, bail out early.

        // If a haptic effect has not been assigned through Open Haptics, assign one
now.
        if (FXID == -1)
        {
            FXID = HapticPlugin.effects_assignEffect(HapticDevice.configName);

            if (FXID == -1) // Still broken?
            {
                Debug.LogError("Unable to assign Haptic effect.");
                return;
            }
        }

        // Send the effect settings to OpenHaptics.
        double[] pos = {0.0, 0.0, 0.0}; // Position (not used for vibration)
        double[] dir = {0.0, 1.0, 0.0}; // Direction of vibration

        HapticPlugin.effects_settings(
            HapticDevice.configName,
            FXID,
```

```
            0.33, // Gain
            0.33, // Magnitude
            300,    // Frequency
            pos,    // Position (not used for vibration)
            dir); //Direction.

        HapticPlugin.effects_type( HapticDevice.configName,    FXID,4 ); //
Vibration effect == 4

        HapticPlugin.effects_startEffect(HapticDevice.configName, FXID );
    }

    void TurnEffectOff()
    {
        if (HapticDevice == null) return;          //If there is no device, bail out early.
        if (FXID == -1)   return;                        //If there is no effect, bail out
early.

        HapticPlugin.effects_stopEffect(HapticDevice.configName, FXID );
    }

    void Update ()
```

```
{
    // If there's no haptic device, bail out early.
    if (HapticDevice == null) return;



    // Toggle on the v Key
    if (Input.GetKeyDown("v"))
    {
        vibrationOn = !vibrationOn;


        //If we've just turned it ON
        if (vibrationOn)
            TurnEffectOn();
        else
            TurnEffectOff();
    }


}


void OnDestroy()
{
    TurnEffectOff();
```

```
}

void OnApplicationQuit()
{
    TurnEffectOff();
}

void OnDisable()
{
    TurnEffectOff();
}

/*
void Update()
{
    // If there's no haptic device, bail out early.
    if (HapticDevice == null)
        return;

    bool buttonState = (HapticDevice.Buttons [0] != 0);

    //If the Button is on and the vibration isn't, or vice-versa
```

```
            if ( buttonState != vibrationOn)
            {
                vibrationOn = buttonState;

                //If we've just turned it ON
                if (vibrationOn)
                    TurnEffectOn();
                else
                    TurnEffectOff();
            }

        }
        */
}
```

Mouse Script

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using UnityEngine.EventSystems;
```

```
public class HapticMouse : MonoBehaviour {



    /*
     *  This is a very simple example of how to use the haptic device as a cursor.
     *  I simply casts a ray to find all UI elements overlapping the stylus tip, and sends mouse-down events. Very basic.
     */


    /* If you need a UI that fits more smoothly with the scene, you may get more elegant results if you put the UI canvas in
     *  the scene, attached to a 'touchable' plane, and then trigger the UI events when the stylus 'touches' it.  That will involve
     *  a little math, but it shouldn't be too bad. And it may be worth it to give the illusion of interacting with an imaginary
     *  touch screen.
     */



    private  HapticPlugin Haptic = null;
    public Camera camera = null;
    public Image cursor = null;


    // Use this for initialization
```

```
    void Start ()
    {
        // find the Haptic Device
        Haptic = gameObject.GetComponent(typeof(HapticPlugin)) as HapticPlugin;
        if (Haptic == null)
            Debug.LogError("HapticMouse script must be attached to the same object as the HapticPlugin script.");

        // Find the camera
        if (camera == null)
            camera = FindObjectOfType<Camera>();
    }

    private bool buttonHoldDown = false; //state, so we can determine between a click and a button that's held down since last frame

    void Update ()
    {
        //This is a "click" if we're pressed now, but weren't last frame.
        bool click = false;
```

```
        if (buttonHoldDown == false && Haptic.Buttons [0] != 0)
            click = true;
        buttonHoldDown = (Haptic.Buttons [0] != 0);



        //Determine the screen position using the stylus position and the camera matrix transforms.
        Vector3 screenPos = camera.WorldToScreenPoint(Haptic.stylusPositionWorld);

        // In this example, the "cursor" is just a UI element.
        // Moving the system mouse cursor is more dificult, and not really recomended.
        if (cursor != null)
            cursor.rectTransform.position = screenPos;



        PointerEventData pointerData = new PointerEventData (EventSystem.current);
        List<RaycastResult> results = new List<RaycastResult> ();

        // Perform a raycast to get a list of all elements under the cursor.
        pointerData.position = screenPos;
```

```
EventSystem.current.RaycastAll(pointerData, results);


// Now that we've found the things. Let's select them ...
bool selectedAtLeastOneThing = false;
foreach(RaycastResult R in results)
{
    GameObject go = R.gameObject;
    Selectable S = go.GetComponent <Selectable>();
    if (S != null)
    {
        S.Select();
        selectedAtLeastOneThing = true;
    }

    // If we've found a button, we can click on it.
    Button B = go.GetComponent<Button>();
    if (B != null)
    {
        if (click)
        {
            B.onClick.Invoke();
            B.Invoke("OnPointerDown",0.0f);
```

```
                }

                if (buttonHoldDown == false)

                {

                    B.Invoke("OnPointerUp",0.0f);

                }

            }



        }



        //If we're not hovering over anything, deselect everything.

        // NOTE : This is pretty crude, and will interfere with anyone trying to operate the UI via keyboard.

        if (selectedAtLeastOneThing == false)

        {

            EventSystem.current.SetSelectedGameObject(null);

        }

    }



}
```

```
using System.Collections;
using UnityEngine.UI;
using System.Collections.Generic;
using UnityEngine;
using System.Linq;
public class ButtonManager : MonoBehaviour
{
public Questions[] questions;
    private static List<Questions> unanswered;
    private Questions current;
    public int score = 0;
    [SerializeField]
    private Text questionText;
    private void Start()
    {
        if (unanswered == null || unanswered.Count == 0)
        {
            unanswered = questions.ToList<Questions>() ;
        }
        SetRandomQuestion();

        void SetRandomQuestion()
            {
            int randomQuestionIndex = Random.Range(0 , unanswered.Count);
        current = unanswered[randomQuestionIndex];

            questionText.text = current.question;
        unanswered.RemoveAt(randomQuestionIndex);
        }

        }
    public void UserSelectviscocity()
    {
        if (current.viscocity)
        {
            Debug.Log("CORRECT!");

        }
        else
        {
            Debug.Log("WRONG!");
        }
    }
    public void UserSelectspring()
    {
        if (current.spring)
        {
            Debug.Log("CORRECT!");

        }
        else
        {
            Debug.Log("WRONG!");
        }
    }
    public void UserSelectvibration()
    {
        if (current.vibration)
        {
            Debug.Log("CORRECT!");
```

```
        }
        else
        {
            Debug.Log("WRONG!");
        }
    }
    public void UserSelectfriction()
    {
        if (current.friction)
        {
            Debug.Log("CORRECT!");

        }
        else
        {
            Debug.Log("WRONG!");
        }
    }
    public void UserSelectfroce()
    {
        if (current.force)
        {
            Debug.Log("CORRECT!");

        }
        else
        {
            Debug.Log("WRONG!");
        }
    }
}
```

Load Scene

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class LoadScene : MonoBehaviour
{
    public void SceneLoader(int SceneIndex )
    {
        SceneManager.LoadScene(SceneIndex);
    }
}
```

```
[System.Serializable]
public class Questions
{
    public string question;
    public bool viscocity;
    public bool spring;
    public bool friction;
    public bool force;
    public bool vibration;
}
```