Faculty of Cognitive Sciences and Human Development

TITLE: MOBILE APPLICATION FOR CHILDREN WITH LEARNING DIFFICULTIES IN MATHEMATICS: AN EXPLORATORY STUDY

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Bachelor of Science With Honours

(Cognitive Science)

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MOBILE APPLICATION FOR CHILDREN WITH LEARNING DIFFICULTIES IN MATHEMATICS - AN EXPLORATORY STUDY

DHIVIYA GOPAL BALAKRISHNAN

This project is submitted

in partial fulfillment of the requirements for a

Degree in Bachelor of Science with Honours

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Faculty of Cognitive Science and Human Development

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(2020)

The project entitled ‘Mobile Application for Children With Learning Difficulties In Mathematics - An Exploratory Study’ was prepared by Dhiviya Gopal Balakrishnan and submitted to the faculty of Cognitive Science and Human Development in partial fulfillment of the requirements for a Degree in Bachelor of Science with Honours (Cognitive Science).

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Date: 31 August, 2020

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ABSTRACT

Word problems are mathematics questions in the form of sentences. A good understanding of word-problems is important because it enables children to answer complex questions more easily. This study focused on the performance of students with mathematics learning difficulties in word-problems. The participants were comprised of ten 9-year-old children (4 females and 6 males). These children were then randomly divided into experimental group and the control group. The intervention group received the Wordie Problem mobile application intervention where else the control group did not receive any. Mann-Whitney U test was used to analyse differences in the performance of the two groups. The participants in the intervention group showed an improvement after the intervention of mobile application was completed. However, there was a significant difference in the student's engagement to learn mathematics. Hence, mobile application was found to be effective for children in learning word-problem questions.

Keywords: word-problem, mobile application, children with mathematics learning difficulties.

ABSTRAK

'Word Problems' ialah soalan matematik dalam bentuk ayat. Pemahaman yang baik tentang masalah perkataan adalah penting kerana ia membolehkan kanak-kanak menjawab soalan kompleks dengan lebih mudah. Kajian ini memfokuskan kepada prestasi pelajar yang menghadapi masalah pembelajaran matematik dalam masalah perkataan. Peserta terdiri daripada sepuluh kanak-kanak berusia 9 tahun (4 perempuan dan 6 lelaki). Kanak-kanak ini kemudian dibahagikan secara rawak kepada kumpulan eksperimen dan kumpulan kawalan. Kumpulan intervensi menerima campur tangan aplikasi mudah alih Wordie Problem di mana kumpulan kawalan tidak menerima. Ujian 'Mann-Whitney U' digunakan untuk menganalisis perbezaan prestasi kedua-dua kumpulan. Peserta dalam kumpulan intervensi menunjukkan peningkatan setelah intervensi aplikasi mudah alih selesai. Oleh itu, aplikasi mudah alih didapati berkesan untuk kanak-kanak dalam mempelajari soalan-soalan masalah perkataan.

Kata kunci: 'word-problem', aplikasi mudah alih, kanak-kanak yang menghadapi masalah pembelajaran matematik.

CHAPTER 1

INTRODUCTION

Mathematical knowledge is obtained by linking previously acquired formula and theories to new information (Hiebert, & Carpenter, 1992). Easily taught by theories and instructional methods for students to understand the flow of solving and back-end understanding of the performed calculation. mathematics depends on an individual's mental ability which defines how to develop the thinking power and reasoning intelligence. It sharpens one's mind and makes it creative (Yadav & Pahi, 2016).

It is widely known that mathematics is necessary and important in an individual's life. Mathematics makes one think analytically and have good reasoning skills. Children are taught mathematics at a tender age as their ability to acquire and process information would be faster and easier. Mathematics becomes complex and complicated as they pass a certain grade, in terms of operations and problem-solving. It enables students to think critically and identify which information is necessary to find the outcome.

According to Geary & Hoard (2005), learning difficulty in mathematics means deficiency in the ability to process and represent information in mathematical domains. Desoete, Roeyers, and De Clercq (2004) stated that learning difficulties in mathematics inhibit an individual in educational opportunities. A students' learning difficulties are not obvious until they enter the primary level and in observation, learning difficulties are projected through reading difficulties. Studies have shown that approximately 6% of children have a mathematical deficiency (Garnett, 1998). They would stay at the same level for quite some time until they gain understanding from a different perspective.

Children with learning difficulties tend to find counting and remembering names of number hard (Grégoire, Van Nieuwenhoven, & Noel, 2003). In cases of proper coaching and

instructions given certain students tend to show positive improvements among themselves. Primary school children can solve simple calculations (2+1 = 3 | 4+2 = 6) without having the use of a calculator or any digital device. Children with this ability have number sense and can compute calculations without help from devices while children with mathematical learning difficulties have a problem with number task.

Children with mathematics learning difficulties require content or experience more than a textbook to be able to understand and overcome the problem-solving questions. learning difficulties could be due to negative affects of developmental delays, representational problems, break downs and retrieval problems (Montague, 2016). Studies have shown that strategies for the representational problem could be overcome by visualizing the content, paraphrasing the content into simpler forms (Hutchinson, 1993).

Word-Problems

Studies have shown that students face learning difficulties in mathematics, especially in word-problem questions. They show difficulties transforming linguistic and numerical information in word-problem into proper mathematical equations and calculations. Children are unable to dissociate the necessary contents. learning difficulties causes an individual to not be able to have critical thinking and abstract thinking for future issues and problems. Future issues in terms of examinations, assignments, calculation of daily expenses and estimation of money balance in a bank account.

Word-problems are a form of mathematics questions that requires children to solve text describing a problem situation and then derive the number sentence representing the situation where the calculation is performed to obtain the answer (Fuchs et al., 2015). An individual's success rate in mathematics problem highly correlates with overall mathematical achievement (Bryant, Bryant, & Hammill, 2000). Word-problem is complex that requires students to

understand, integrate, create and maintain mental representation images of the problem, and develop a solution path (Montague, Warger, & Morgan, 2000).

Strategies to learn Mathematics Word-Problems

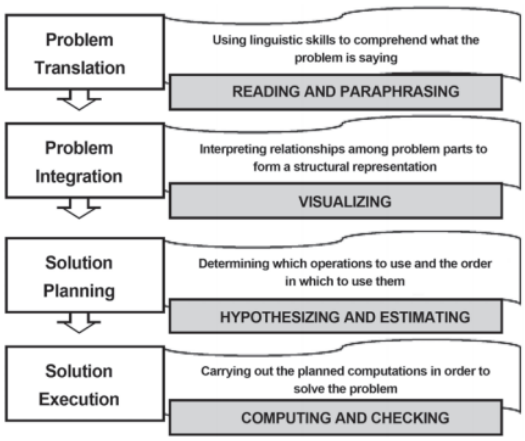


Figure 1. A problem-solving process. From "The Effects of Cognitive Strategy Instruction on Knowledge of Math Problem-Solving Processes of Middle School Students With Learning Disabilities" by Curriculum, C., & All, T. (2015). Media Rich Instruction. In *Media Rich Instruction*. https://doi.org/10.1007/978-3-319-00152-4

Problem-solving strategies for children with learning difficulties is presenting explicit and guided instructions that represents real-life issues. Figure 1 displays the modal of the problem-solving process. The process identifies four sequential phases: The first phase is problem translation (using linguistic skills to understand what the problem is saying), followed by problem integration (mathematical analysing the relationships between the sections of the question to construct a structural representation), the third phase is solution planning (deciding which operations to use and the sequence in which to use them), and the final phase is solution execution (performing the calculation planned to solve the problem). The correct calculation can be obtained by understanding the problem and performing the right process.

Contextual comprehension skills are cognitive skills that help an individual solve word-problem with multiple sentences. The sentences are in bulk where some of it may be relevant

to need of the question or otherwise which makes us ponder on whether we need it or not. Comprehension skills are helpful for children dealing with semantic linguistic word-problems where the relationship between the words are made explicit (Marzocchi et al., 2002). Children with mathematics learning difficulties face problem in enabling this skill due to cognitive complexity (Desoete et al., 2004).

To acquire and tackle problem-solving question easily, one has to have **mental representation skills** to be able to represent the task. A simple change of keywords in a problem (e.g., "less") into calculation procedures (e.g., "subtraction") without representation leads to blind calculation (Desoete et al., 2004). The problem-solving question which contains a lot of words requires mental representation to simplify the words into keywords and calculation terms. Words represent some internal meaning which is then translated into operation to solve the task. Coherent and rich mental representation containing the solution related elements creates a deeper understanding of the word-problem (Pape, 2003). It helps one solve the problem easily within a short period. Children with low mental representation are considered having learning difficulties.

Based on Desoete, Roeyers, & De Clercq (2004), indicate that **relevance skills** are important in solving word-problem where question contains relevant and irrelevant information. An individual who has relevance skills can screen the relevant information and discard the irrelevant information (example, William has 13 red cards and 4 black cards. Jane had 5 red cards more than William. How many red cards does Jane have?). Based on the example, the black card is irrelevant to the task requirement. Irrelevant information in a story-based word-problem causes the student to find it difficult to remember the previously taught problem and apply an effective strategy to solve the question (Wang, 2016). Lacking relevant skills leads to learning difficulties where children have difficulties in ignoring the information

and discarding it while they perceive that all numerical have to be used to solve the calculation. Students fail to attempt the word-problem questions due to unsureness of the values and tend to add or subtract and multiply all the numbers in the questions (Wang, 2016).

Number sense means having the ability to estimate without calculating the exact answer. Studies have shown that all children with athematics LD have problems with number sense tasks (Sowder, 1992). Possessing number sense helps an individual to understand the meaning of numbers and creating suitable strategies to solve complex word-problem (Danial, 2009). Dehaene (1997), stated that number sense is developed and present in infancy where it develops with or without verbal input or instruction, and it is present in infancy. Number sense brief screen is positively correlated with mathematics achievement

Gamification in education

Gamification is defined as "using game-based mechanics, aesthetics and game design to engage people, inspire action, encourage learning, and solve problems." (Kapp, 2012). The current generation is digitalized natives that may have a high interest in gamified learning. Studies have shown that Mobile gamification learning system improves student's performance and encourages the student to engage more in the learning activities than classroom textbook learning.

In the current education system, children tend to have a lack of engagement and motivation due to a lack of interest in the teaching techniques. In other words, game approaches lead to high chances of student motivation and commitment in a particular subject. Student's engagement can be sustained when rewards are given in return for their achievement and results. Users will obtain motivation to win the game (objective) in the presence of the problem (task) and obstacles. Based on Su and Cheng (2014), gamified learning has increased achievement of students.

Gamification Theories

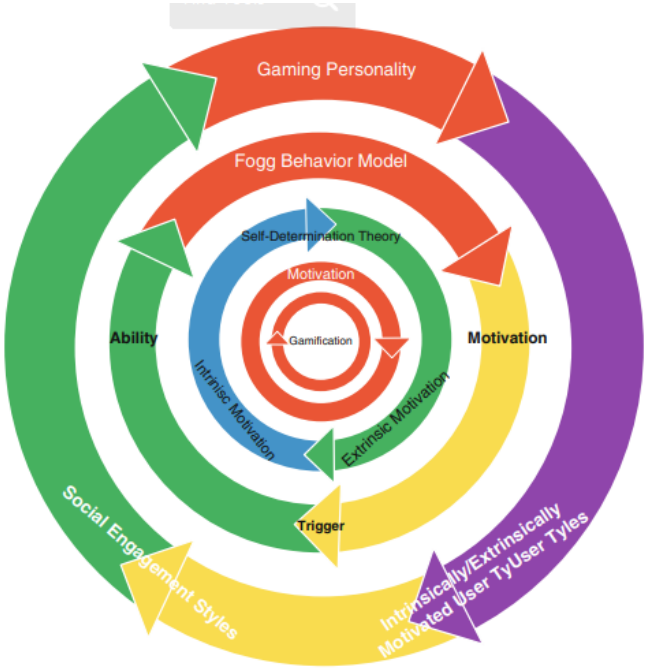


Figure 2. A Gamification theory. From "Curriculum, C., & All, T. (2015). Media Rich Instruction. In *Media Rich Instruction*. https://doi.org/10.1007/978-3-319-00152-4"

Motivation is the key to attract children to be involved in learning (Su & Cheng, 2015). Engagement and participation in using Mobile gamification are based on the context of the games and the information which is ready to be delivered. The game is to be designed in a competitive nature to allow students to have the urge to participate more and pass each level of the task. Children portray a high level of interest when the design is attractive, interactive and contains high multimedia contents. The motivation increase as rewards and applications upgrades by level. Children can track their performance (Kiryakova et al., 2014). Thus, would increase children's interest to achieve a higher target.

Self-determination theory is a form of motivation that human behaviour possesses Intrinsic and extrinsic motivation are the drives that and individual inherits (Curriculum & All, 2015)Self – determination defines human's capacity to act in a certain manner and achieve (Su & Cheng, 2015). Intrinsic motivation is an example of self-determination (Ryan & Deci, 2000) and influences ones' academic success (Wilson & Corpus, 2005). It evolves from within an

individual to achieve. At a competitive level, the confidence and ability to complete the task is self-determination which increases intrinsic motivation (Su & Cheng, 2015).

Fogg's Behavioural Model (FBM) studies on how to enable learners to balance between boring to motivating activities related to the easy and complex task (Kiryakova et al., 2014). The model contains 3 elements: motivation, ability and triggers, that which if occurs together can achieve targeted behaviour. The motivation and ability to learn and solve are achievable when triggered behaviour threshold is met (Muntean, 2011). Motivation is developed by social and self-influences. An individual with the strength to solve the problem but lack of motivation faces difficulties in achieving the result. Ability is defined as to be able to perform a task through practise and training. High motivation can ensure individual find possibilities to accomplish the task. A simplified task increases the ability of children to reach targeted behaviour. Gamified activities can be made simpler in three ways; Divide and conquer (dividing the complex task into simpler forms), Cognitive rehearsal/guidance (showing the way of completion of the task and easy it is), and Cascading information (reading the information in smaller parts to gain a good understanding level. Behaviour needs to be triggered to complete the task at the moment. Inlay man's term trigger defines spark which tends to motivate them to learn.

Cognitive theory of Multimedia Learning

The multimedia learning environment is learning where learners learn from words and pictures which improves students teaching (Mayer, 2002). Cognitive theory of multimedia learning is used to examine how people learn from pictures and words. Multimedia learning instructions helps learner build better mental representation.

Assistive Technology

Assistive technology is defined as any technology that helps people with disabilities enhance their performance. A wide range of alternatives provided consisting of both "low" technologies and "high" technology devices designed for people with disabilities and generic technology for the public (Lewis, 1998).

Mobile application is a software program developed in a mobile device such as a smartphone. Children who have learning difficulties can use and access smartphones due to easy to use, user-friendly and interactive software with the multi-touch aspect (Kraleva, 2017). They tend to explore the mobile in a way that is natural to them (touch, trial, error then repeat (Papadakis & Kalogiannakis, 2017). The mobile application has been proven as beneficial education application in recent studies (Diah et al., 2010). Education can be embedded by delivering the necessary content through mobile devices. Significant mobile learning is to learn and have fun at the same time that enables the student to learn more efficiently and faster (Diah et al., 2010). Based on a previous study, the development of mobile application and their consistent usage have improved their performance in mathematical skills (Kalloo & Mohan, 2012).

Design Interface for mobile application for children is required to be easy and interactive for their understanding. Children from the age of 2 to 4 face difficulties to focus on mobile devices and computer, while children above the age of 5 enjoy winning and having fun (Kraleva, 2017). The simplified design is better for children to understand the following steps. Icons and widgets are required to be designed bigger for children to identify them more easily. An important feature in designing for children are colours, where the application should contain a mixture of colours. The background and icon colours should contra to differentiate it (Kraleva, 2017). Music and sound make an application more engaging for children. Communication and interaction of children with the application are created through music and

sounds. Based on the previous study, the task should be easy for children and the continuation step should be visible with clear instruction.

Purpose of the current study

The purpose of the present study was to identify the improvement of solving word-problem on the intervention group by using the mobile application and to examine the engagement of students in using the gamified mobile application. The mobile application is treated as a useful educational tool to help children learn, solve and read. Besides, understanding of mathematical operation is also examined in this study. There are two specific research questions:

1. Did the intervention group improve significantly in comparison to the control group after using the mobile application on solving word problems?
2. Was the mobile application engaging for the students?

Significance of the study

The study contributes to solving word-problems of children who have mathematical learning difficulties at School A. A mobile application was developed as an assistive technology for children to solve word-problems. There were pros and cons involved in using the mobile application among teachers and parents. The researcher can examine whether assistive technology is suitable to help children with mathematical difficulties to solve word-problems. Solving word-problems enables children to develop critical thinking and abstract thinking for further progress in education and employment. Children between the ages of nine and ten were selected as participants. It is an age where word-problems are taught and early intervention is necessary for children with mathematical difficulties.

Summary

A child's ability to solve mathematical word-problems is important because story-based word-problems are used in daily life. Children who can solve word-problems can think abstractly and seldom encounter problems in the further part of life. Children who can read can easily focus on and understand the main information and discard the unnecessary ones.

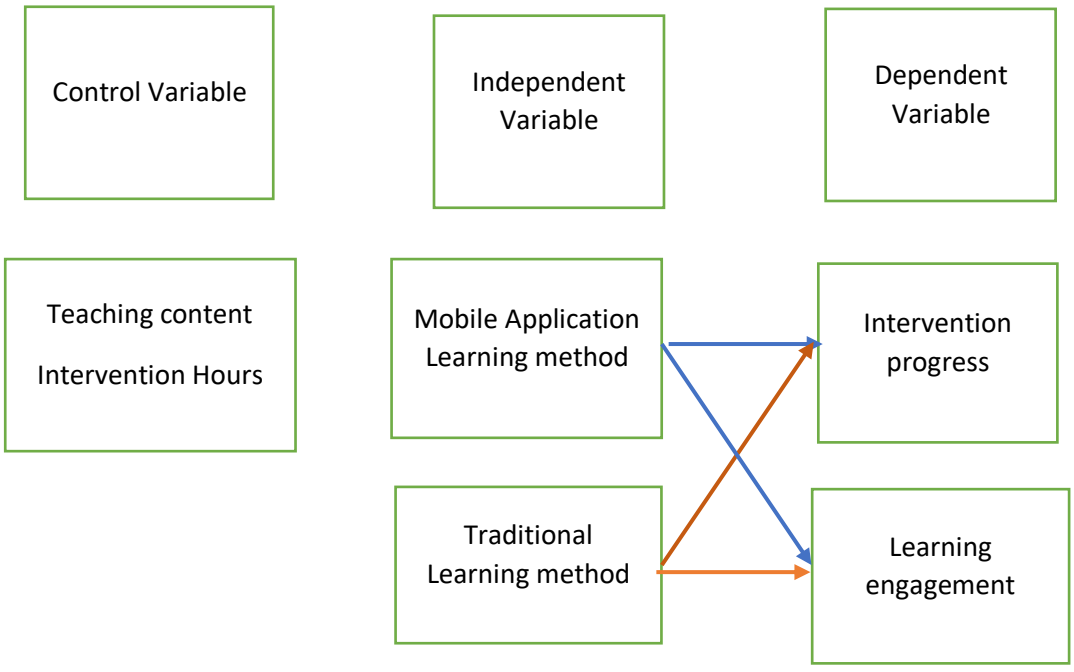
CHAPTER TWO METHOD

Research Design

This research was an **experimental study** where the results were collected through a quantitative study. The study was to investigate the word-problem in mathematics among primary school children with mathematical learning difficulties. This experimental study was conducted to examine the improvement of word-problem understanding through gamified mobile application word –problem intervention.

Research Framework

The independent variables are the teaching methods where the experimental group used the mobile application while the control group used the traditional method. The dependent variables are the learning engagement and intervention progress. The control variable is teaching content which is the word-problem questions from school textbooks and exercise books, while the intervention hours is 30 minutes for each student in the pre-test and post-test. Figure 3 shown is the research framework.



Population, Sample and Sampling procedure

Population. The targeted population were students from School A, Bandar Sunway. The school is located in Petaling Jaya.

Sample and sampling method. The sample group for word-problem intervention were students at the age of 9. 10 students were participating in this study with 6 male and 4 females. Five students are Malay and five are Indian. They were chosen as samples because word-problems are taught at the age of 8 and the intervention at age 9 could reduce word-problem errors among students. The sampling method was through experimental research of pre-test and post-test. The participants were selected by purposive sampling. Students with mathematical difficulties who participated in the study were referred by teachers. This sampling method was chosen to improve the word-problem difficulties among children with learning difficulties. The inclusion criteria was that the children selected had average literacy in Bahasa Malaysia.

System Development Phase

The gamified mobile application was developed using Android Studio. Android studio is a platform to create a simple mobile application to be used in an Android phone. It is very user friendly and contains a lot of plugins. The mobile application usability testing will be carried out in during pilot testing. The usability of the mobile application will be evaluated using the System Usability Scale (SUS) questionnaire by Brooke (1986). The usability of an application or device is measured using the SUS questionnaire.

Research instrument

The questionnaire was Adapted from "The Effect of Mobile Applications on English Vocabulary Acquisition", (2014). It consists of 6 items and 4 subscales, which are effectiveness (3 items) and confidence (3 items). The questionnaire uses a 5-point Likert scale to measure the engagement of the student in using the mobile application where "1" is Strongly Disagree