A RULE-BASED REASONING TECHNIQUE ON MATHEMATICS TUTOR DESIGN FOR CHILDREN WITH AUTISM

SITI NUR AZRREEN BINTI RUSLAN

MASTER OF SCIENCE IN INFORMATION AND COMMUNICATION TECHNOLOGY

2017

Faculty of Information and Communication Technology

A RULE-BASED REASONING TECHNIQUE ON MATHEMATICS TUTOR DESIGN FOR CHILDREN WITH AUTISM

Siti Nur Azrreen Binti Ruslan

Master of Science in Information and Communication Technology

2017

A RULE-BASED REASONING TECHNIQUE ON MATHEMATICS TUTOR DESIGN FOR CHILDREN WITH AUTISM

SITI NUR AZRREEN BINTI RUSLAN

A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Information and Communication Technology

Faculty of Information and Communication Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this thesis entitled "A Rule-Based Reasoning Technique on Mathematics Tutor Design for Children with Autism" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Siti Nur Azrreen Binti Ruslan

Date : 27 – 07 – 2017

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature	:	.....
Supervisor Name	:	Dr. Gede Pramudya Ananta
Date	:	27 – 07 – 2017

DEDICATION

To my beloved mother, father and family.

ABSTRACT

Autism is a complex developmental or neurodevelopmental disorder which also affect in learning difficulties (Aliee et al., 2013; Ge and Fan, 2017). Even though autism can cause a variety of challenges, individuals diagnosed with autism also have potential, skills, abilities and talents (Understandautism.org, 2016). Therefore, it is important to search for an effective intervention that can help and improve the lives of the individuals with autism (Lindgren and Doobay, 2011) such as Computer-Assisted Intervention (CAI). Most children with autism use visual elements to help them maintain information (Meadan et al., 2011) besides the parents and doctors often indicated that children with autism are attracted to technology tools. Thus, selection of the suitable fonts, colours and images for the CAI is important to ensure that CAI can help students with autism to stay focus and engage throughout the lesson. Besides that, the selection of suitable technique is also important to ensure CAI present suitable learning material according to students with autism skill level. Therefore, this study proposed to develop the Mathematics Tutoring System (MTS) using rule-based technique, and to examine the effectiveness of MTS in helping students with autism to study the concept of addition in mathematics. Thus, an experimental case study was employed to gain data from the participants. The participants were divided into two groups, the intervention and the control group. The data obtained from the experimental case study were analysed using the Mann-Whitney Test to determine whether there is a significant difference between both groups before and after the experiment. According to the results, the value of ($U = 11.50$, $p<0.05$) obtained using the Mann-Whitney Test shows that there is a significant difference between the intervention and control group. In other words, the result shows that method used by intervention group is a more effective method than the control group. In conclusion, the MTS can help the students with autism to learn maths addition skills because the methods used such as images, animations, and sounds helps participants to memorise the lesson besides attracting them to participate and engage during the lesson. Besides that, the MTS can represent a controlled environment which makes students with autism feel comfortable in which may improve their maths skills together with the problematic behaviour.

ABSTRAK

Autisme merupakan penyakit gangguan perkembangan otak atau neurodevelopmental kompleks yang berterusan dan kekal serta turut menyebabkan masalah pembelajaran (Aliee et al, 2013;. Ge dan Fan, 2017). Walaupun autisme menngakibatkan pelbagai cabaran, individu yang disahkan menghidap autisme juga mempunyai potensi, kemahiran, kebolehan dan bakat tersendiri (Understandautism.org, 2016). Oleh itu, adalah penting untuk mencari intervensi yang berkesan serta boleh membantu meningkatkan taraf hidup individu autisme (Lindgren dan Doobay, 2011) seperti Intervention Computer-Assisted (CAI). Kebanyakan kanak-kanak autisme menggunakan unsur-unsur visual untuk membantu mereka mengekalkan maklumat (Meadan et al., 2011) selain daripada ibu bapa dan doktor sering menunjukkan bahawa kanak-kanak autisme tertarik kepada alat teknologi. Oleh itu, pemilihan fon, warna serta imej yang sesuai untuk CAI adalah penting untuk memastikan bahawa CAI boleh membantu pelajar dengan autisme untuk kekal fokus dan melibatkan diri di sepanjang sesi pengajaran. Selain itu, pemilihan teknik yang sesuai juga penting untuk memastikan CAI membentangkan bahan pembelajaran yang sesuai mengikut tahap kemahiran pelajar autisme. Oleh itu, kajian ini mencadangkan untuk membangunkan Sistem Tutor Matematik (MTS) menggunakan teknik berasaskan peraturan, dan juga memeriksa keberkesanan MTS dalam membantu pelajar dengan autisme untuk mempelajari konsep penambahan dalam matematik. Oleh itu, satu kajian kes bereksperimen telah digunakan untuk mendapatkan data daripada peserta. Para peserta dibahagikan kepada dua kumpulan, kumpulan intervensi dan kawalan. Data yang diperolehi daripada kajian kes bereksperimen dianalisis menggunakan ujian Mann-Whitney untuk menentukan sama ada terdapat perbezaan yang signifikan antara kedua-dua kumpulan sebelum dan selepas eksperimen. Menurut hasil kajian, nilai ($U = 11.50$, $p < 0.05$) yang diperolehi dengan menggunakan ujian Mann-Whitney menunjukkan bahawa terdapat perbezaan yang signifikan antara kumpulan intervensi dan kawalan. Dalam erti kata lain, hasilnya menunjukkan bahawa kaedah yang digunakan oleh kumpulan intervensi merupakan kaedah yang lebih berkesan daripada kumpulan kawalan. Kesimpulannya, MTS boleh membantu pelajar dengan autisme untuk belajar konsep penambahan dalam matematik kerana kaedah yang digunakan seperti imej, animasi, dan bunyi membantu peserta untuk menghafal pelajaran di samping menarik minat mereka untuk mengambil bahagian dan melibatkan diri dalam pelajaran. Di samping itu, MTS juga boleh mewakili persekitaran yang terkawal dimana menjadikan pelajar autisme berasa selesa sehingga boleh meningkatkan kemahiran matematik mereka serta tingkah laku yang bermasalah.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my sincere gratitude to my supervisor and co-supervisor Dr. Gede Pramudya Ananta and Dr. Halizah binti Basiron from the Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka (UTeM) for the continuous support of my thesis, for their patience, motivation, and immense knowledge. They guidance helped me in all the time of research and writing of this thesis.

Besides that, I would like to thank respondents for their insightful comments and encouragement. The comments and encouragement helped me during designing and developing Mathematics Tutoring System.

Special thanks to my parents and family for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

Lastly, thank you to everyone who had been to the crucial parts of realization of this project. Not forgetting, my humble apology as it is beyond my reach personally mentioned those who are involved directly or indirectly one to one

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATION

ABA	Applied Behaviour Analysis
CAI	Computer-Assisted Intervention
CDD	Childhood Disintegrative Disorder
CTAT	Cognitive Tutor Authoring Tools
ESDM	Early Start Denver Model
ES	Expert System
HCI	Human-Computer Interaction
ITS	Intelligent Tutoring System
MTS	Mathematic Tutor System
NASOM	National Autism Society of Malaysia
PDD-NOS	Pervasive Developmental Disorder – Not Otherwise Specified
UI	User Interface
VSVBC	Microsoft Visual Studio Premium 2012 with Visual Basic Compiler
xPST	Extensible Problem-Specific Tutor

LIST OF PUBLICATIONS

1. Ruslan, S.N.A., 2017. Using Computer-Assisted Intervention to Improve Mathematical Learning of Autistic Students. *International Journal of Innovative Science and Research Technology (IJISRT)*, 2(6), pp.55-57.

2. Pramudya, G., and Ruslan, S.N.A.B., 2017. Using computer-assisted intervention to improve mathematical learning of students with autism. In: *Proceedings of Mechanical Engineering Research Day 2017*, Malacca, Malaysia, 30 March 2017. Centre for Advanced Research on Energy, pp.235-236.

3. Ananta, G.P., and Ruslan, S.N.A., 2016. Using Computer-assisted Intervention in Helping Student with ASD to Learn Addition Skill. In: *2nd International Congress On Technology - Engineering & Science (ICONTES)*, Kuala Lumpur, Malaysia, 28-29 July 2016. – *to be publish*

CHAPTER 1

INTRODUCTION

1.1 Overview

Autism has been categorised as an intricate developmental or neurodevelopmental disorder that affects communication skills, behaviour, and socialisation ability (Pellicano, 2017). In addition, individuals diagnosed with autism are also having learning difficulties (Ge and Fan, 2017). Since autism is a spectrum disorder and affects people in a wide degree of variation (Smith, Segal and Hutman, 2016), each individual diagnosed with autism has some unique features as well as its own advantages and disadvantages. Therefore, some would exert mild symptoms, while others have moderate to severe ones, which reflect their inability to function in the society due to their impairments. Even though autism can cause a variety of challenges, individuals diagnosed with autism also have potential, skills, abilities and talents (Understandautism.org, 2016). Hence, it is important to search for an effective intervention that can help and improve the lives of the individuals with autism (Lindgren and Doobay, 2011).

Furthermore, Corsello (2005) claimed that each intervention program is based on a distinctive philosophy and adopts unique intervention strategies, which focus on support and learning environment for individuals with autism besides helping them replace the difficult behaviour with more appropriate behaviour. In addition, these interventions involve all parties associated with autistic individuals. Besides using common interventions such as behavioural intervention, developmental intervention and combined

intervention, technology-based intervention also has been used on the children with autism to improve their academic skills (Knight et al., 2013; Massaro, 2003; Ramdoss et al., 2011; Vilaseca et al., 2013; Yaw et al., 2011). In the past, technology-based interventions usually used as an assistive tool (Knight et al., 2013) or temporary instructional aid to treat children with autism (Goldsmith and LeBlanc, 2004). Moreover, the studies on the use of technology to teach students with autism are not a new concept and it has been done for over 35 years (Knight et al., 2013).

1.2 Research Background

According to BERNAMA's report as cited in an article published by Time Money (2016), it is estimated that one out of every 600 children in Malaysia is born with autism. Children with autism are having various challenges in their lives due to their disabilities in which include learning difficulty (Aliee et al., 2013). Despite having learning difficulty, children with autism can be taught through an integrated and organised education program. Besides that, their learning patterns are unique compared to normal children due to other problems related to autism itself, such as behavioural problems, emotional, social, communication, and cognitive skills.

Intervention refers to any action, for instance, a treatment, a therapy or the provision of a service that is specifically designed to help those diagnosed with autism spectrum (Researchautism.net, 2015). Intervention may include educational programs, new or stronger policies, increase in environmental or health promotion campaigns. Interventions that include a variety of strategies are usually the most effective in producing the desired change and sustainable. Interventions can be implemented in different settings, including the community, work site, school, health care organisation, or even at home.

Evidence has shown that intervention makes a difference by influencing individuals' knowledge, attitudes, beliefs and skills; increasing social support; and creating supportive environments, policies and resources (Bosseler and Massaro, 2003; Konstantinidis et al., 2009; Koegel et al. 2010; Knight et al., 2013; Vilaseca et al., 2013). There are several types of early interventions used to help children with autism in education, such as behavioural, developmental, therapy based, combined, or family based (Autism Awareness Australia, 2016).

Besides that, vast studies have been conducted to investigate a variety of applications from the stance of technology-based interventions involving children with autism (Goldsmith and LeBlanc, 2004). In addition, according to Alja'am and Jaoua (2011), children with autism who are facing learning difficulty can be helped by giving them the suitable support, different learning materials, or even just some encouragement. The most studied technology-based intervention for children with autism is Computer-Assisted Interventions, or also known as CAI.

Additionally, CAI has been used widely to help children with special need to enhance their skills (Goldsmith and LeBlanc, 2004; Knight et al., 2013). One of the first studies conducted by Colby (1973) which intended to enhance students' understanding of how letters and sounds form words, and how words can form expressions using various computer games. The computer games are organised at various levels of complexness. The author indicated that 13 of the 17 children participated shown an increase in involuntary speech, enjoyment, and motivation. After that, there are a lot of studies have been done to demonstrate that children with autism learn better through interactive CAI.

1.3 Problem Statement

As mentioned earlier, autism is a complex neurodevelopmental disorder which influences the development of communication skills, behaviour, and socialisation ability (Aliee et al., 2013; Pellicano, 2017). Even though CAI might shorten children with autism social and communication interaction, they learn better through interactive CAI. It is because the CAI increases the children with autism motivation, and enhances their engagement and interest throughout the learning session (Knight et al., 2013). Numerous studies have been carried out to develop a tutoring system and test its effectiveness in helping students with autism improve academic skills. However, most research concentrated on the literacy skills such as reading, grammar and story writing (Ramdoss, Mulloy, et al., 2011; Knight et al., 2013; Vilaseca et al., 2013) compared to mathematics skill.

Furthermore, most children with autism use visual elements to help them maintain information (Meadan et al., 2011). Besides that, parents and doctors often indicated that children with autism are attracted to technology tools. Therefore, selection of the suitable font for the CAI is important to ensure that CAI can help students with autism to focus and stay engage throughout the learning sessions. This is because the learning style for students with autism are different from ordinary peers. They must be guided along the learning session. Therefore, with the selection of colours and font sizes that are suitable, it can increase the effectiveness of the tutors help students with autism during a learning session. In addition, the selection of suitable technique is also important to ensure CAI present suitable learning material according to students with autism skill level. Therefore, this study proposed to develop the CAI using rule-based technique which will determine the

learning material based on students with autism skill level, and to examine the CAI in helping students with autism to study the concept of addition in mathematics.

1.4 Research Questions

Research questions are listed in Table 1.1.

Table 1.1: Research questions and objectives

Research Questions	Research Objectives
1. What are the characteristics of children with autism? 2. What are the problems faced by children with autism? 3. What types of interventions that are offered specifically for children with autism?	1. To construct the taxonomy of the characteristics of children with autism.
4. What authoring tools available to develop MTS? 5. Which authoring tools are suitable to develop MTS?	2. To design and develop a Mathematics Tutoring System, or MTS, for students with autism to learn addition concept in mathematics.
6. Do students with autism who participate perform slightly different after the intervention?	3. To examine the effectiveness of rule-based approach in helping students with autism improving their skills.

1.5 Research Objectives

The objectives of this study are:

a. To construct the taxonomy of the characteristics of children with autism.

b. To design and develop a Mathematics Tutoring System, or MTS, for students with autism to learn addition concept in mathematics.

c. To examine the effectiveness of rule-based reasoning technique in helping students with autism improving their skills.

1.6 Research Scope

This study aims to develop and examine the effectiveness of a tutor system, Mathematics Tutoring System (MTS), which uses rule-based reasoning technique in helping students diagnosed with autism to learn basic addition skills. In order to develop the MTS, interviews with several special education teachers will be carried out to get the fundamental views on autism which includes the methods and learning patterns of children with autism as well as the materials used in the learning process. Besides that, formative evaluations will be used to get feedback from the teachers involved on the prototype of MTS that has been developed. Next, an experimental case study involving two groups of 20 students diagnosed with autism will be carried out to examine the effectiveness of the rule-based reasoning technique used in MTS. At the end of the experimental case study, Mann-Whitney Test (Jaykaran, 2010) will be used to analyse the data gained. Alongside with Mann-Whitney Test, the Wilcoxon Signed-Rank Test was used in order to determine whether there is a significant difference between the pre-test and post-test scores before and after the experiment of the control group and the intervention group.