A Conceptual Framework Study of Learning Mathematic Word Problem Solving using Virtual Reality Environment for Children with Autism

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ABSTRACT

Helping students with autism spectrum disorder (ASD) achieve competence in mathematical problem solving has proven challenging because it related to various aspects of academic and cognitive factors. In order for students with ASD to succeed in the mathematics curriculum, there is a need to focus on mathematical word problem solving ability and the interventions that may help to improve this ability and will have the potential to perform academically. Hence, this study intend to reveal the conceptual framework mathematics word problem abilities among autistic children and learning intervention solution.

1. INTRODUCTION

Autism spectrum disorder (ASD) is a syndrome which resulted in children suffering from disabilities in self-development, problems of communication, behavior and even process information differently from normal children. According to the statistics from National Autism

Society of Malaysia (NASOM), showed an increasing number of children registered with autism in Malaysia. Due to the fact, there is a demand for assistive technologies that will help to improve the daily function of the children.

Meanwhile, the acquisitions of solving mathematical word problem (MWP) has been long recognized as an essential components of mathematics competency by National Council of Teachers of Mathematics (NCTM). MWP is important as it encompasses skills and functions which are important part of everyday life. However, MWP is a challenging task for children with ASD as it requires not only mathematics skills but also reading comprehension, memory organization and real-world reasoning (Rockwell, Griffin, & Jones, 2011) . Relatively little is known about MWP competencies in children with ASD and the importance of mathematics intervention for this children.

The application of technology, curriculum planning which considers the needs and learning problem of children with ASD, and common sense approaches which acknowledge and

leverage the user's strengths are critical tools for successful educational outcomes (Hughes, 2015). The use of virtual reality (VR) as an educational tool for students with ASD is a line of research that has been have been developed over the last decade (Good, Parsons, Yuill, & Brosnan, 1999; Strickland, 1997). VR researchers concurred that VR technology is suited to the educational needs of individuals with ASD (Ke & Lee, 2016). The technology have shown the improvement of cognitive abilities of children with special needs via a more supported by self-directed exploration of the virtual environment thus enable constructionist learning approach by the student-centered learning opportunities (Kalyvioti & Mikropoulos, 2012).

Hence, this paper intends to propose a virtual reality learning model for learning MWP skills of children with autism. Specifically, this study sought to find out a twofold aim: (a) what are the mathematics problem solving abilities among autistic children, and (b) how virtual reality environment can be integrate with mathematics problem solving learning process.

2. BACKGROUND AND RATIONALE

Most of the autism studies have been carried out to improve their communication and social skills(Parsons, 2015;Wong et al., 2014). It is seen that there is a lack of studies on academic areas for these students, especially in mathematics and science. Early identification of problems with the MWP enables early treatment given to the student. Therefore the learning problems can be assist with appropriate teaching methods which will lead to positive consequences for their future lives and vocation.

The following section will brief the conceptual framework in which the study is conducted. The framework study comprised of (i) the study of MWP abilities among autistic children and (ii) the intervention solution of using VR learning environment for MWP solving skills acquisition. The conceptual framework of study is presented as shown in figure 1 below. The finding of this study will propose a VR learning model for learning mathematics problem solving of children with autism.
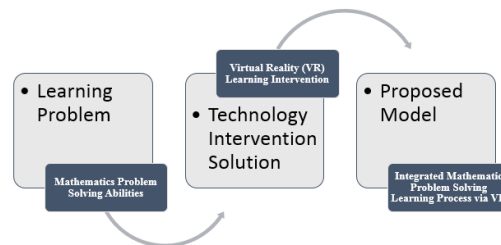

Figure 1. Conceptual Framework

2.1 MATHEMATICS WORD PROBLEM (MWP) ABILITIES

Standards for School Mathematics emphasizes a strong understanding of mathematics concepts, high degree of procedures knowledge, and the ability to apply mathematics knowledge to solve real-world problems (National Council of Teachers of Mathematics (NCTM), 2000), therefore students with and without disabilities are expected to develop the ability of the mathematics skill as required by the standards. Helping children with ASD in achieving their competence in MWP solving has proven challenging because it relates to various aspects of academic and cognitive factors (Wei, Christiano, Yu, Wagner, & Spiker, 2014).

MWP is a mathematical exercise where the information of the problem is presented as text instead of the mathematical notation. MWP requires students to use both semantic and counting skills for problem solving (Rockwell et al., 2011).However, researchers have shown that students with autism have difficulty making use of semantic information (Frith & Snowling, 1983) due to their language impairment. Moreover, MWP often include the contextual knowledge or information that likely to encounter in their everyday lives. Due to their limited experience with community (Bae et al., 2015; Wei et al., 2014) and also their restricted and repetitive patterns of behavior, interest or activities (*Diagnostic and Statiscal Manual of Mental Disorders(DSM-V)*, 2016), the learning process will be a challenging task for the children.

In terms of academic, children with ASD may be associated with mathematical ability, but their Intelligence Quotient (IQ) may not predict their mathematics competency (Estes et al.,2011; Mayes & L.Calhoun, 2008). Autistic children with IQ >80 or HFA may show weakness in

MWP solving. This assumption has supported by an empirical study (Iuculano et al., 2014) which has found above average performance on basic calculation skills but average performance on mathematical reasoning in a group of children with ASD with no intellectual impairment. Along similar lines, Jones et al., (2009) examined a subtest of mathematical reasoning and found low-average performance in math word problems for HFA children,

Mathematical reasoning is the critical skill in learning mathematics skills because to learn skills that are easily remembered, can be applied when needed and can be adjusted to solve new problems, they must learn by understanding. Hence, when solving MWP, students will apply their knowledge to realistic problem situations where mathematical reasoning became an important instrument for making concrete judgments.

2.2 VIRTUAL REALITY LEARNING ENVIRONMENT

Virtual reality (VR) is an emerging learning platform attracting the attention of both educational researchers and practitioners. Virtual reality (VR) functions as a computer-generated 3D representation of a real-life learning environment (X. Wang, Laffey, Xing, Ma, & Sticher, 2016). Within VR environments, the variety of hands on experiences will enable the learner to apply mathematics concepts that they have learned in the classroom. VR has been used to teach students with ASD and successfully improving specific problem behavior for autism in term of social behavior, attention and safety but yet there is still slow development in targeting cognitive impairments among this children (M. Wang & Reid, 2013).

The main benefits of using VR are define as threefold (1) VR allows a user to experience real-life situations (X. Wang et al., 2016), (2) VR can promote the sense of social presence(Stichter, Laffey, Galyen, & Herzog, 2014) in the cyberspace, (3) Embodiment in VR will award a user the self of presence that can promote higher cognitive engagement with other avatars (Dalgarno & Lee, 2010). The characteristics of active, authentic, and contextualized learning processes derived from the interactive experiences in VR can help user to comprehend conceptual ideas easier (Cecil, Sweet-Darter, & Cecil-Xavier, 2017). It is seen the method is aligned with the aspects of constructivism (Chen, 1995; Daghestani et al., 2012), suggesting that VR technologies can be integrate in learning MWP learning process in order to build ASD children's understanding in the context of mathematics knowledge in real life problems. The VR experience is expected to produce a development of problem scheme to assist the children in solving MWP.

2.3 PROBLEM SCHEMA

Kochen et al.,(1983) introduced schema-induction theory which explains how people induce a general schema from experiences with specific objects or events. The important of schema theory is that the problem schema can be formed through the induction as a result of experiencing various instances of general solution principle or rule.The broader the schema developed, the greater probability the children will recognize connections between novel and familiar problems; thus they will know when to apply the solution methods they have mastered(Fuchs et al., 2008).

3. METHODOLOGY

3.1 THEORETICAL STUDY

In the process of developing the research aims, an initial study will be conducted. The analyses of the study support the formulation of problems and the main aim of this research. An in depth understanding of learning problem in mathematics word problem solving acquisitions for autistic children will be conducted in this phase. The study will look into the integration of virtual reality application technology in mathematic word problem solving learning process as part of treatment which will enable problem schema development among the children.

Expert Consultation
Expert consultations will be conducted in order to provide empirical evidence from autism educator and instructor. The main purpose of this activity is to identify the components and phases involved in mathematic word problem solving learning process.
Model Design
A conceptual model will be designed as a medium to validate and evaluate the effectiveness of proposed design for problem schema development for autism children utilizing virtual reality application as a basis. This prototype will be used as a learning tool in mathematics problem solving skills acquisitions among the children.

Experimental Study
Experimental study will be performed on a real project to measure the practicality aspect, and therefore this can assist for validating the proposed design guideline model. The problem solving worksheets and multiple probe across participants design will be used as a method to gain the testing result from the children. The Evaluation will take place at the National Autism Society of Malaysia.

4. SUMMARY

This proposed project will help the researcher to further extend her research area in the usability of media interactive in special needs education. This investigation will be a momentous endeavor and will be very theoretical for learners with autism and other related disabilities. This scaffold will eventually help educators, facilitators and curriculum to create appropriate instrument and instructional programs for the benefit of this underprivileged community in overcoming problems in learning disability. Completion of this project will contribute to the diversity of technologies usability in education area and continue to enhance the researcher's research field in computer technology.

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