

# *A Proposed Conceptual Framework of Word Problem Comprehension using Virtual Reality for Children with Autism*

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**Abstract**—The goal of word problem comprehension is to develop the meaning described in the mathematical word problem. Envisioning the events occurred in the text is essential for generating an accurate situation model of the narrative text. As children with autism spectrum disorder (ASD) relate to various aspects of academic and cognitive factors, helping them to competence in word problem comprehension is challenging. The study intends to reveal the conceptual framework of word problem comprehension among autistic children by using virtual reality learning technology. In developing research aim, understanding of learning abilities of word problem solving among these children was conducted. The study looks into the integration of virtual reality in word problem learning as part of the treatment which will support the children in comprehend the problem situation. Completion of this project will contribute to the diversity of technologies usability in special needs education area.

**Keywords**— *autism; mathematics; word problem; virtual reality; situation model*

## I. INTRODUCTION

Autism spectrum disorder (ASD) is a syndrome which resulted in children suffering from disabilities in self-development; problems of communication; behavior and even processing information differently from normal children. According to Center for Disease Control (CDC) in the United States; the incidence of autism is 1 in 68 children and it is estimated that 9,000 children in Malaysia are born with autism every year (National Autism Society of Malaysia) [1]. ASD commences during the early year of children life; and research on developmental disabilities for children with ASD has shown that the functionality between cognitive; language; communication; and social differences is nuances. Baron-Cohen; Leslie; & Frith; (1985); Frith & Happé; (1994) noted

that children with ASD experience difficulties in cohesively processing and understanding social and affective information; such as attention; information processing and social cognition are often impaired. ASD also characterized difficulties with information integration; abstract reasoning; and flexibility with cognitive functioning [4].

The education of ASD in the classroom environment has become increasingly common and ASD student placement in general education has increased faster than other categories of disability [5]; [6]. Although the Individual Education Plan (IEP) goal is to provide special need education services to these children; there is an expectation that the students will follow the same core curriculum content with their typically developing peers and this calls the need for effective educational interventions to help the children progress in academic learning [7].

In recent years; there has been an increasing interest in helping ASD children excel in mathematics learning. Mathematics is an important academic skill for all students including ASD children for a successful self-independence in life functioning and social community [8]–[10]. Among the researcher's interest is on word problem (WP) solving. WP is a mathematical exercise that relates real-life problems solution to mathematics concept which is presented in the form of text rather than in the form of mathematical notation. WP is important as it encompasses skills and functions which are the important part of everyday life [9]; [11]–[14]. However; WP 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 [15]. Relatively little is known about WP solving competencies among children with ASD. Early identification of problems

with the WP enables early treatment to be given to the student. Therefore; the learning problems can be assisted with appropriate teaching methods which will lead to positive consequences for their future lives and vocation.

Meanwhile; the application of technology in 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 [16]. The use of virtual reality (VR) as an educational tool for students with ASD is a line of research that has been developed over the last decade [17]. VR studies concurred that VR technology suits the educational needs of individuals with ASD as the technology enables the constructionist learning approach by the student-centered learning opportunities [18]. Most of the studies; however; focus solely on improving specific problem behavior for autism in term of social behavior [19]; [20]; attention [21]; [22] and safety [23]; [24] but there is still slow development in targeting content area.

Hence; the objective of this paper is to reveal a proposed conceptual framework of word problem comprehension learning by using VR technology for autistics children. Specifically; this study seeks to find out a twofold aim: (a) What are the word problem-solving abilities among autistic children; and (b) how virtual reality environment can be integrated with the word problem-solving learning process.

## II. LITERATURE REVIEW

### A. Word Problem (WP) Abilities

The standards for School Mathematics emphasize a strong understanding of mathematics concepts; high degree of procedures knowledge; and the ability to use knowledge of mathematics to solve real-world problems [25]. Therefore; regardless of students with or without disabilities; all are expected to develop the ability of the mathematics skills as required by the standards. Helping children with ASD in achieving their competence in WP solving has proven to be challenging because it relates to various aspects of academic and cognitive factors [11]; [26].

WP is a mathematical exercise where the information of the problem is presented as text instead of the mathematical notation. WP requires students to use both semantic and counting skills for problem-solving [15]. However; studies have shown that students with autism have difficulty in comprehending the problem situation or semantic information [27]–[29] due to their language impairment. Moreover; WP often includes the contextual knowledge or information that the children may encounter in their daily life [11]; [26]; [30]; [31]. Hence; due to their limited experience with community and also their restricted and repetitive patterns of behavior; interest or activities [32]; the learning process will be a challenging task for the children.

In terms of academic; children with ASD's Intelligence Quotient (IQ) may not predict their mathematics competency.

Notwithstanding; children with ASD may be considered to be mathematical gifted. Iuculano et al.; (2014) has revealed children with ASD showed better performance on basic calculation skills compared to mathematical reasoning and problem-solving. This finding is consistent with findings of past studies by [34]–[36] which found that autistic children with IQ>80 or High Functioning Autism (HFA) may show weakness in WP solving and mathematical reasoning. Mathematical reasoning is related to WPS ability as the skill helps in understanding the problem situation and making an adjustment to solve a new problem. Hence; when solving WP; students will apply their knowledge to realistic problem situations where mathematical reasoning became an important instrument for making concrete judgments.

### B. Potential Affordances of Virtual Reality Learning Environment

Virtual Reality (VR) is an emerging learning platform of digital and physical domains which has been successfully developed to facilitate learning [37]–[39]. The mechanism as a 3D representation of real life learning environment capable of creating anything imaginable and users can be part of the environment [40]. The VR learning environment is experiential and intuitive; thus offers a unique learning experience similar to hands-on learning; simulation and concept visualization.

In recent years; VR was suggested for ASD intervention by means of VR-based interactions between human-computer interaction tasks. VR has several strengths; namely experiential; controllability; replicability; sensory; stimulation; and ability to intervene and enhance individualized learning strategies. The main benefits of using VR are defined as threefold: (1) VR allows a user to experience real-life situations [40] (2) VR can promote the sense of social presence in the cyberspace [40]; [41] (3) Embodiment in VR will award the user the self of and presence that can promote higher cognitive engagement with other avatars [42]. Furthermore; the characteristics of active; authentic; and contextualized learning processes derived from the interactive experiences in VR can help the user to comprehend conceptual ideas easier [43].

### C. How VR learning environment assist students in improving their comprehension of mathematics word problems?

The virtual reality (VR) learning environment benefits from the strength of the ASD people as a visual learner. To facilitate the creation of mental representations; the VR learning environment provides the learner with a virtual scenario representing text information in the word problem. The visual content in a controlled format can be explored and interact repetitively. The experience of a virtual scenario as the feeling of 'being there'; allows children with ASD to actively participate in interactive and immersive simulated situations. For example; in a virtual scenario of the buying and selling of goods or services; it will provide students with a

sense of presence in the situation of the selling and buying activities. As the student practices the mathematics activities; they experience mathematical knowledge on a daily basis and build their contextual information. In addition; vision and sound were effective in teaching abstract concepts with autism in particular [17]; [44].

Interactiveness in the VR system; which results from user - avatar interactions; can support the development and representation of mental models. VR can stimulate imagination including a reminiscence of images or concepts of object; event; and situation that are constructed by combining previous interactions with situation and objects mentally. It is helpful in the construction of the problem situation because the text of information and world knowledge interact continuously [45]. In this regard; VR has the potential to support the learners during word problem understanding in generating accurate mental representation or situation model. Visualizing and developing the situation model thus allows the learner to clarify the semantic information in the text. This affects the comprehension of the word problem by the students.

It is seen the method is aligned with the aspects of constructivism [46]–[48]; and suggested that VR technologies can be integrated into learning WP in order to build ASD children's understanding of the context of mathematics knowledge in real life problems. The VR experience is expected to produce development of problem situation to assist the children in solving WP.

**D. Problem Situation**

Understanding a narrative text requires the reader to form a mental representation or situation model [45]. Situation model is the mental representations of the event in text generated by readers as they read. According to [45]; there is a continuous interaction between text information and world knowledge during the construction of the situation model. Readers often rely on the background knowledge and knowledge of vocabulary before making any conclusions to understand their reading materials. Hence; without correct mental representation; little comprehension or understanding will be achieved. Furthermore; research conducted has proven that mental visualization supports reading comprehension [49]; [50].

In order to develop an accurate representation of the situation in the text; relevant background information has to be available and active in students memory [51]. Research has noted that children with poor prior background knowledge scored lower in comprehension assessment [52]. It was supported by finding by Norman (2014) where children's mental representation is based upon their prior knowledge and experience. Thus; it can be concluded that when the children have sustained a considerable amount of prior knowledge; the more likely they will understand the problem presented in the text.

**E. Conceptual Framework**

The framework study is comprised of (i) the study of WP abilities among autistic children and (ii) the intervention solution of using VR learning environment for WP skills acquisition. (iii) the development of mental situation through VR support. The conceptual framework of the study is presented in Fig.1 below. The finding of this study is to propose a VR learning model of learning WP for children with autism.

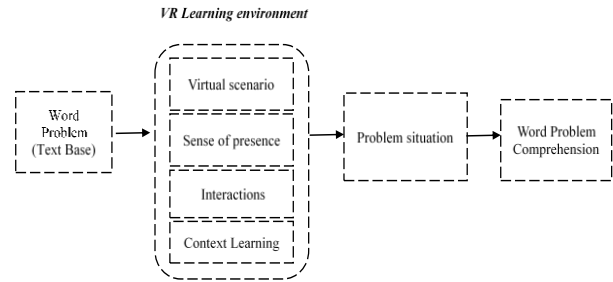


Fig.1- Conceptual Framework

**III. METHODOLOGY**

In the process of developing the research aims; an initial study is to 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 among autistic children is to be conducted in this phase. The study is to look into the integration of virtual reality application technology in mathematics word problem-solving learning process as part of treatment which will enable problem schema development among the children.

**A. Theoretical Study**

**i. Model of Motivation**

This proposed project incorporates Keller's ARCS Model of Instructional Design which outlines four elements in order to promote motivation during the learning process. The elements are attention (A); relevance (R); confidence (C) and satisfaction (S). The affordances of VR in developing situation model are illustrated in Fig 2.

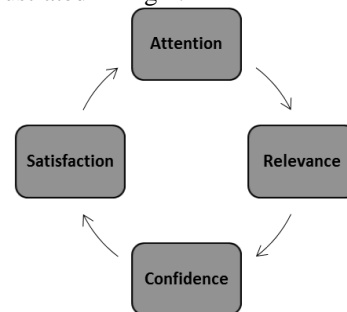


Fig. 2- ARCS Model

### ii. Schema Theory

Kochen et al.;(1983) introduce schema-induction theory which explains how people induce a general schema from experiences with specific objects or events. The importance of schema theory is the problem schema can be formed through induction formed by past experiences in various instances of general solution principle or rule. It is believed that children with broader schema development has the greater probability the children to recognize connections between the novel and familiar problems; thus they will know when to apply the solution methods that they have mastered [54].

### iii. Constructivist Learning

Constructivist theory suggests that meaningful learning is a successful learning process through engagement and reflection of authentic experiences. VR emphasizes the importance of active learning in the learning process. Furthermore; Dickey; (2005) as cited in [55] noted that constructivist theory can have an influence in enhancing the VR learning environment.

### B. 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.

### C. 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.

### D. 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.

## IV. SUMMARY AND CONCLUSIONS

This proposed project aims to investigate whether virtual reality can enhance the accuracy of problem situation development and support word problem comprehension. Given the favorable outcomes that visual supports can assist in the development of situation models and the perceived affordances of virtual reality by generating mental representation; the researcher hypothesis that the use of virtual reality can support the creation of accurate situation models thus improve reading comprehension. This project is to 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 applicable for learners with autism and other related disabilities. This scaffold is to eventually help educators; facilitators; and curriculum to create an 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 the education area and continue to enhance the researcher's research field in computer technology.

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