COMPUTER-ASSISTED INTERVENTION (CAI) TO ENHANCE MATHEMATICAL LEARNING OF AUTISTIC STUDENTS: A CASE STUDY IN MELAKA

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Abstract

Purpose of the study: To evaluate the efficacy of a CAI called MathTutor in helping autistic students to learn addition in mathematics.

Methodology: A pre-post-test experimental model was employed in the study. The study participants included three autistic male students who possessed all the prerequisite skills.

Main findings and novelty: The study participants were found to have been benefitted which indicates that MathTutor improves their learning abilities as an effective instructional strategy. The use of CAI enabled the participants to memorise their lessons and actively take part during the entire lesson.

Applications of this study: The study is beneficial for people involved in caring for autistic students with the help of computer assisted application. This will ease the burden of the carer takers of autistic children in dealing with their conditions while at the same enabling them to navigate the world.

Keywords: *Autism, Computer-Assisted Intervention, Concept of Addition, Mathematics Skill*

INTRODUCTION

In scientific terms, autism can be described as an intricate developmental disorder that affects communication skills, behaviour, and socialisation ability. Additionally, persons diagnosed with autism also experience learning problems (Ge & Fan, 2017). Considering that autism is known as a spectrum disorder and is affecting people in a diverse degree of variance (Smith, Segal, & Hutman, 2017), every person diagnosed with autism has some unique features which have its own advantages and drawbacks. Consequently, some would exert mild symptoms, while others possess moderate to severe ones, which reflect their lack of ability to function in the society due to their impairments. Even though autism can cause a variety of challenges, persons diagnosed with autism also have potential, skills, abilities and talents (Understandautism.org, 2016). There are five main types of autism which includes (a) Classic Autism (Autistic Disorder), (b) Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), (c) Asperger's Syndrome, (d) Childhood Disintegrative Disorder (CDD), and (e) Rett Syndrome.

Based on a report by BERNAMA cited in an article published by Time Money (Lee, 2016), one out of every 600 children born in Malaysia has been identified to suffer from autism. Therefore, it is vital for persons with special needs to learn basic skills for independent living and also to ascertain them to continue living without expecting help from others. Considering the limited ability possessed by autistic students to achieve educational skills, a special curriculum is employed specifically to cater to the needs of these children. Additionally, autistic students have shorter concentration span, thus giving importance to visual learning (e.g. images along with videos) to assist them grasp information (Meadan, Ostrosky, Triplett, Michna, & Fettig, 2011). Besides that, parents and doctors have often indicated that autistic children are attracted to technology tools.

Consequently, it is essential to seek out an effective intervention that can help and improve the lives of the autistic persons (Lindgren & Doobay, 2011). Alja'am and Jaoua (2011) reported that autistic children who are experiencing learning difficulties can be assisted by providing them with suitable assistance and various learning materials, with some encouragement. According to Corsello (2005), each intervention program is founded on a distinctive approach and

adopts unique intervention strategies, which focus on support and learning environment for autistic persons apart from supporting these persons replace the challenging behaviour with more proper behaviour. Apart from employing normal approaches to educate autistic students, in-depth studies have also been carried out on the use of Computer-Assisted Intervention (CAI) to educate these persons for more than three decades. CAI has been implemented on autistic children to improve their communication skills (Costa et al., 2011; Hetzroni & Tannous, 2004; Ploog, Scharf, Nelson, & Brooks, 2013; Lang, et al., 2011), social skills (Hopkins et al., 2011; Hourcade, Bullock-Rest, & Hansen, 2012; Hourcade, Williams, Miller, Huebner, & Liang, 2013; Lang, Ramdoss, Machalicek, & Rispoli, 2016), as well as academic skills (Coleman-Martin, Heller, Cihak, & Irvine, 2005; Knight, McKissick, & Saunders, 2013; Mulloy, et al., 2011; Smith, Spooner, & Wood, 2013).

In the past, CAI was normally employed as an assistive tool (Knight et al., 2013) or as a temporary instructional support to treat autistic children (Goldsmith & LeBlanc, 2004). Furthermore, studies concerning the use of CAI to educate autistic students are not new as the research interest has been in existence for the past 35 years (Knight et al., 2013). Nonetheless, the majority of studies focused on literacy skills, for instance reading, grammar and story writing (Grindle, Hughes, Saville, Huxley, & Hastings, 2013; Knight et al., 2013; Ramdoss, Mulloy, et al., 2011; Whitcomb, Bass, & Luiselli, 2011; Yaw et al., 2011). Goldsmith and LeBlanc (2004) also described that CAI is generally utilized to improve problem solving skills, strengthen vocabulary, advance generative spelling, improve vocal imitation, develop play-related reasons, and also boost reading and communication skills among autistic students.

Apart from literacy skills, numeracy skills such as addition, subtraction, fundamental knowledge of money and time, should likewise be given particular attention because these skills can help autistic children to live independently. Following immersion of general and commercial or non-commercial customised CAI for mathematical skills since 1997, a computer-based treatment, using TeachTown®, was compared to the traditional treatment of teacher-led instruction using data from pre- and post-testing as well as observation, and was shown to improve both pupil attentiveness (time on task) as well as mathematics test scores (Hansen, 2014). The current study was carried out to analyse the efficacy of MathTutor, a local-customised CAI with use of particular local examples, context or setting, in assisting autistic students in learning simple arithmetic skills.

LITERATURE REVIEW

One of the first scientific studies carried out to analyse the use of computers to teach autistic students was carried out by Colby (1973), who pointed out that parents and doctors often report that autistic children are attracted to technology tools. Besides, previous research has also mentioned the importance of designing treatments by taking advantage of this attraction. Hence, the author used a computer program which contains various computer games that happen to be organised at various levels of complexity. The study aimed to boost students' understanding of how letters and sounds form phrases, and how phrases can form expressions. The author found that 13 out of the 17 children displayed an increase in involuntary speech, enjoyment, and motivation, which supports the claim that autistic children are fascinated by technology tools.

Meanwhile, other studies suggest that autistic children learn better through interactive CAI. For example, Bosseler and Massaro (2003) designed and analysed a computer-animated tutor using their own theoretical framework to educate autistic children on vocabulary and grammar. The experts pointed out that all the participants showed an increase in recognition precision once the training was employed. After that, the participants exhibited generalisation of the learned vocabulary to new instances of the vocabulary items either immediately or after just a few training sessions. Furthermore, the participants were able to generalise their knowledge from the computer program to an independent review by an instructor.

Others studies reflect on how the autistic individuals "think in pictures" and use visuals (e.g., pictures and videos) to help them maintain information (Meadan, Ostrosky, Triplett, Michna, & Fettig, 2011). Rahman, Ferdous, and Ahmed (2010) designed and analysed a computer-animated tutor to enhance vocabulary and grammar in autistic children. In the study, eight participants were given preliminary evaluation assessment and tutorials, and were then reassessed after 30 days following expertise of the vocabulary items. The results showed that the participants were able to recognise significantly more items during the test and recall 85% of the recently learned items at least 30 days after the completion of training. In addition, Alja'am and Jaoua (2011) conducted a study to analyse the application of multimedia elements to disabled children. The objective of the study was to strengthen the children with disability, make them self-reliant and guide them in understanding the concept of living. The experts discovered that the images used in the tutorial can make them understand more easily.

Yaw et al. (2011) conducted an extended study on a computer-based sight-word reading intervention (CBSWRI) on an autistic student. The result of the study supports the efficacy of the CBSWRI besides the interest of the participant to take advantage of the CBSWRI to learn to read correctly. Furthermore, the study conducted by Massaro, Bosseler, and Light (2003) on computer-animated tutor for language and vocabulary learning showed that the participants learned many new words, grammatical constructions and concepts. These results proved that the computer-animated tutor is effective for autistic children in improving language and vocabulary.

The effect of CAI on literacy skills were found to be inconsistent; some studies show significant results, while other studies show no improvement. Thus, it can be said that autistic children enjoy interacting with computers as the computers do not have any expectations and are not judgmental which could make social interactions problematic. Computers play an important role in autism education process as it represent a controlled environment which makes autistic children have certain level of control over the environment (Konstantinidis, 2009), which in turn help to improve the participant behaviour. However, it depends on the participant's learning history involving computers and motor skills (Ramdoss et al., 2011). Besides that, an interactive learning environment can motivate the student to learn (Bosseler & Massaro, 2003; Konstantinidis, 2009).

METHODS AND MATERIALS

Participants

The experiment was done on three male students, aged 7 to 10, diagnosed with autism who attended the special education class in Ayer Keroh, Melaka. The participants were expected to possess certain prerequisite qualities, including the ability (a) to follow instructions orally or in written form, (b) to use a computer with a computer mouse, (c) to recognise figures between 1 and 10, as well as (d) to focus on the activity no less than 10 minutes.

Besides, while in the process of selecting participants, pre-interviews were performed with the teachers and general information about the potential participants had been retrieved. Later, the participants were observed individually to verify if they did portray the required skills for the experiment. At the end of the observation period, three male autistic students who met these skills were selected as participants for the experiment.

Ethical Consideration

Considering that autistic students are vulnerable participants in this experiment, careful attention was given. The study was designed by balancing between expected sampling and measurement techniques for quality research, besides devising an overall security strategy to ensure the effectiveness of the study. Additionally, during the experiment, voluntary participation was ensured. The autistic students were required to obtain written permission in order to take part in the experiment when they showed sufficient proficiency to do so. Consent forms signed by their parents or guardians were obtained.

Environment Setting

The experiment took place in an individualised education classroom using a laptop with a computer mouse to present the intervention modules. In other words, during the experimental session, no other person was allowed to be in the classroom other than the researcher and the participants. Prior to each and every session, the purpose of the experiment was explained to the participants. Besides that the participants were assisted and prompted every time they gave an incorrect answer. At the initial stage of the first session, the participants were instructed to sit for the pre-test. Finally, during the last session of the experiment, the participants were instructed to sit for post-test.

Procedures

The experiment comprised of seven sessions that made use of a laptop and a computer mouse. Before each session, the objective of the experiment was elaborated to the participants. During the first session of the experiment, the participants were informed that the experiment has three stages: pre-test, learning session, and practice session. As for the next six sessions, the participants were informed that the experiment consisted of only two stages: learning session, and assessment session. During the last session of the experiment, the participants were informed that it was the last session, and that they had to sit for post-test.

Materials

CAI was used to present both the assessment and learning modules throughout the experiment session. The learning modules included tutorial, examples, and reinforcement exercises. During the learning module session, three examples

were presented to the participants before they were asked to attempt the reinforcement exercise, which contained six questions. Next, ten randomly selected questions were presented to the participants in the assessment module. Upon answering each question, the participants had to submit their answer before proceeding to the next question. After submitting the answer, the participants were informed if their answer was correct or otherwise so as to alert the participants about their errors.

RESULTS AND DISCUSSION

Though the time taken to execute this experimental case study was short, all the participants demonstrated promising results at the end of the experiment. Based on the evaluation, the results indicated that there was a notable improvement in the overall performance of the participants through the entire experiment. Nonetheless, there were a number of sessions where the participants' scores slightly decreased, however these scores were still within the predetermined performances.

This outcomes demonstrate that the technique employed in the CAI is effective. In precise, it can help autistic students to learn the addition skill in mathematics since the approaches employed in it, such as images, animations, and sounds, helped the participants to memorise the lesson, other than to attract them to take part and engage in the lesson. Moreover, the active involvement shown by the participants during the lesson emerged as a major aspect in enhancing their achievement. Besides, the CAI can represent a controlled environment mainly because the participants enjoy the learning environment, thereby improving their mathematical skill despite the challenges they face as autistic children.

The experiment was carried out in seven sessions and the participants displayed enhancement in their addition skills, most likely because they have already been exposed to the addition concept. Thus, the CAI has improved their addition skills. This finding is in agreement with that asserted by Coleman-Martin et al. (2005), in which, for the majority of students, the initial teaching should begin with teacher-directed instructions before CAI can be employed for further practice or reinforcement of skill development.

The scatter plot in Figure 1 illustrates the distribution of pre-test and post-test scores of participants individually. Figure 2 illustrates the line plot of performance of each participant during the experimental sessions. The plot in Figure 1 demonstrates that scores of all participants increased. Participant 1 demonstrated an increase of 30%; participant 2 demonstrated an increase of 35%; and participant 3 demonstrated an increase of 35%. Additionally, it demonstrates that learner with the lowest score (third participant) benefited from the experiment by demonstrating an increase in scores. These findings indicate that there was significant improvement before and after the experiment which suggest that the use of CAI can help to enhance autistic students' skills in long-term.
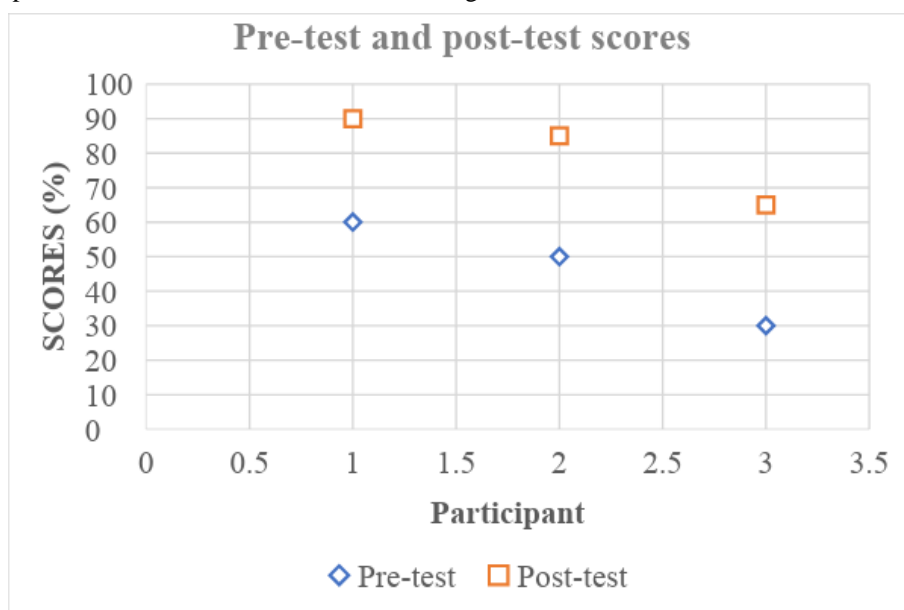

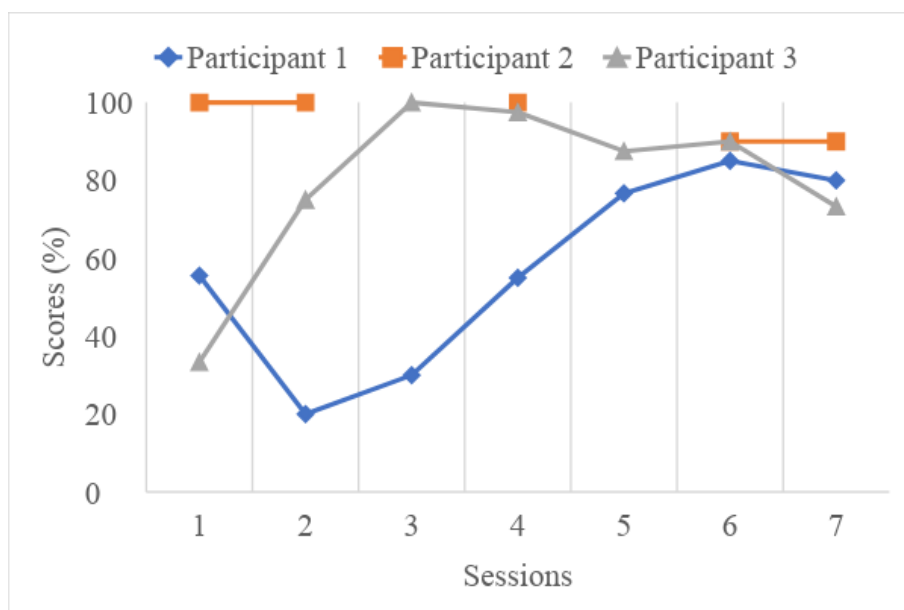Figure 1. Scatter plot of pre-test and post-test scores

Figure 2. Line plot of participants' performance during experimental session

Participant 1

Participant 1 obtained 60% in the pre-test which revealed that he already possessed the fundamental knowledge about addition in mathematics. During the first couple of experiment sessions, Participant 1 appeared playful and also needed assistance to remain engaged throughout the entire session even though he showed interest in the use of computers as a learning tool to learn addition skill in mathematics. Throughout the first experiment session, Participant 1 obtained 55.56% scores on the assessment which he had completed. While in the third session, the graphical images employed in CAI began to catch the attention of Participant 1. Participant 1 began to focus and show a marked improvement in scores during the third session. Additionally, the scores for Participant 1 continued to increase from the third session onwards. Participant 1 obtained 30% in the third session; 55% in the fourth session; 76.67% in the fifth session; and 85% in the sixth session, respectively. During the last experimental session, the scores of Participant 1 dropped slightly to 80% due to the interference from the surrounding. Throughout the entire experiment, Participant 1 accomplished the target levels of performance after six sessions and the scores increased to 85%. At the end of the experiment, Participant 1 can be said to have learned the concept of basic addition skills with assistance and guidance from the teacher. Additionally, during the post-test, the scores for Participant 1 increased from 30% to 60% to 90%. In general, considering the progress made by the participant, it can be inferred that he demonstrated a good potential in strengthening and sustaining the addition skill which shows that the CAI appeared to be effective for him.

Participant 2

During the pre-test, Participant 2 revealed that he already possessed the fundamental knowledge about addition with a score of 50%. Despite having very poor reading skills, Participant 2 recognised numbers and had high mathematics skills. Besides, he also showed interest in the application of computers as a learning tool to learn addition skill in mathematics. Nevertheless, through the entire experiment, Participant 2 had missed a couple of sessions; third and fifth session. Regardless of missing two sessions, it did not influence his overall performance in the following session. Participant 2 obtained 100% in the first, second and fourth sessions; and 90% in the sixth and seventh sessions. These were mainly because throughout the entire experiment, Participant 2 exhibited an outstanding ability to recall the examples and instructions of the previously session. Therefore, Participant 2 managed to solve the exercises that need reading based on the example that were given in the early stage. There are times when students with ASD have to deal with certain problems such as they get easily disturbed by the environment, and also require guidance and assistance. Participant 2 was not found to be bothered by these problems. However, there was a decrease in the average scores of Participant 2 due to his carelessness during calculation. Apart from that, during the experiment, Participant 2 showed good behaviour throughout the entire remaining experimental sessions when compared to the first session. At the end of the experiment, Participant 2 learned the concept of basic addition by scoring 85% in the post-test. This proposes that CAI was beneficial for Participant 2.

Participant 3

During the pre-test, Participant 3 obtained 30% which revealed that he possess only a basic understanding about addition in mathematics. Apart from that, Participant 3 also showed curiosity about the use of computers as a learning tool to learn addition in the beginning of the experiment session. During the first session, Participant 3 attained 33.33% scores on the assessment which he previously completed. For the following two sessions, Participant 3 began to demonstrate an increase in the scores throughout the entire experiment sessions aside from demonstrating an outstanding ability to recall the examples and instructions from the previous session. These helped him to go through the exercises and the assessments in the next session. In the second session, the scores for Participant 3 increased to 75%. In the third session, the scores for Participant 3 continued to increase to 100%. However, during the remaining sessions of the experiment, the scores of Participant 3 slightly dropped due to the miscalculation made during the assessment. In the fourth session, the scores of Participant 3 decreased to 97.5%. In the fifth session, the scores of Participant 3 further decreased to 87.5%. However, in the sixth session, the scores increased to 90%. Furthermore, during the experiment, Participant 3 achieved the target performances after three sessions. On the other hand, at the end of the experiment, the scores of Participant 3 dropped resulting from non-pictorial questions by which he seemed to be lost and struggled to solve the assessment. Even so, Participant 3 can be said to have learned of the skills of addition with minimum guidance or assistance from the teacher. Due to the fact that Participant 3 has been viewed as a potential student in academics by the teacher; however, occasionally he faced difficulties due to 'Autism' itself, and he also required guidance and assistance. No exception for Participant 3, when he started to lose focus and played with 'function buttons' in CAI, which occurred during the fifth session. During the post-test, Participant 3 obtained 65%, a slight increase from 35%, compared to the pre-test scores. Considering the average scores for this overall experiment session, Participant 3 demonstrated good results and improved his addition skills in mathematics. This suggests that CAI was effective for Participant 3.

CONCLUSIONS

As stated earlier, autism is an intricate developmental disorder that influences communication skills, behaviour, socialisation ability and also learning abilities (Pellicano, 2007). Individuals diagnosed with autism possess some unique features that comes with its own challenges. Moreover, since autistic children have problems with imagination, communication, and interaction, they also have problems in interpreting their emotions towards others and others' emotions towards them. Therefore, it is crucial to search for an efficient intervention program that can help them to improve the lives of individuals diagnosed with autism (Lindgren & Doobay, 2011).

CAI has the potential of producing unfavourable outcomes. For instance, decrease in interaction and communication among the autistic students and with other individuals. Nonetheless, this situation can be overcome by interacting with them through asking questions and providing them with instruction and guidance on the use of CAI. As a result, there will be some interaction and communication between the autistic students and the teachers.

Apart from that, CAI can boost the autistic children's motivation level, and improve their involvement and interest through the entire learning session (Knight et al., 2013). Specifically, CAI can assist autistic students to learn the addition in mathematics, considering that the techniques utilized in CAI, for instance images, animations, and also sounds, made it much easier for the participants to be able to memorise the lesson, other than attracting them to take part and also to engage in the lesson. On top of that, the active participation demonstrated by the participants during the entire lesson appeared as a major aspect in strengthening their achievement. These discoveries support the findings made by Yaw et al. (2011) which discovered that the participants enjoy the treatment and it was beneficial for them in improving their skills.

Considering that the vast majority of autistic students tend to be visual learners (Aliee et al., 2013), the approaches utilized in the CAI included animations, images as well as sounds that can capture interest and engage them throughout the entire learning session. The tutorials and examples shown to them managed to catch their attention and help them to memorise the lesson learned. Additionally, their interest as well as attention towards the CAI lesson can help to reduce most of their behavioural problems. These findings support the experiment done by Bosseler and Massaro (2003), which showed that the students involved in the intervention were able to generalise their vocabulary knowledge to novel images, and the knowledge can be transferred outside the intervention.

In summary, CAI can act as a critical element in autism education approach to enhance the autistic students' academic skills as it can represent a controlled environment and make these students feel to have a certain level of control over the environment (Konstantinidis, Luneski, Frantzidis, Costas, & Bamidis, 2009). As a result, the CAI can be utilised as tools

to further improve the autistic students' interest towards mathematics in addition to enhancing their mathematics skills. Long term usage of CAI as a learning tool can help increase the student's interest towards academics and improve their academic performance. Since only three participants were involved in this study, the findings may not be generalizable. Therefore, a considerably bigger sample with more number of participants is recommended for the future studies for improving their external validity.

LIMITATION AND STUDY FORWARD

The present study involved a small number of participants and was conducted within a limited time of investigation. This may limit the external validity of the findings. Significant number of participants is required in the future in order to improve the generalizability of the findings and contribute more along this line of research.

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