Mathematics Education for Students with Autism Apectrum Disorders

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Abstract

"The main goal of Mathematics education in schools is the mathematisation of a child's thinking." -National Curriculum Framework 2005

Autism spectrum disorder (ASD) is a developmental disorder which is neurological and lasts throughout a person's life affecting the overall health of the affected individual that is cognitive, emotional, social and physical aspects, beginning early in childhood. However, any individuals with ASD are found to exhibit intellectual abilities varying from person to person. This present paper attempts to study mathematics education for children with autism spectrum disorders. The researcher adopted a synthesis of literature review to study mathematics education and a systematic analysis of mathematics interventions for students with ASD. Limited number of Studies related to instructional interventions in mathematics was found for students with ASD. The need to receive help in studying of mathematics for students with ASD was highlighted. Interventions that targeted specific skill mathematics areas for individuals which were explicit and systematic were often found to be more effective. Repeated practice and rehearsal with specific targeted skills were recommended in order to be able to help the students with ASD achieve their academic goals in mathematics. Practical Implications for practitioners are also discussed which can help the students not only in strengthening their mathematics skills but also help in completing problems independently, and use acquired skills in applied settings or other community.

Key Words: *Mathematics Education, Mathematics Intervention, Strategies, Autism Spectrum Disorder*

Introduction

Autism spectrum disorder (ASD) is a neuro- developmental disorder which is neurological and lasts throughout a person's lifetime affecting the overall health of the individual that is cognitive, emotional, social and physical aspects. It begins early in childhood affecting a child's ability to communicate, socialize and process sensory information. An individual with ASD may experience restricted interests and repetitive behaviours that adversely affect the educational performance. It impairs the area of the brain that is responsible for communication and social interaction. The impairments may range from mild to profound resulting in high functioning

individual to low functioning individual. A high functioning individual with autism characterises with a high IQ, verbal and social while a low functioning individual with autism may be completely nonverbal, mentally retarded and not social at all. ASD typically appears before three years of age and the child may have difficulty with organising their responses and are more likely to have associated leaning difficulties. Autism is found to be four times more prevalent in boys than in girls and the chance of its occurrence is not affected by life styles, race, ethnic cultures or social boundaries. The Centres for Disease Control in the USA (2007) reported that as many as one in every 110 people suffers from autism. 1 to 1.5% is autistic between children of ages 2 to 9 in India as per the survey of International Clinical Epidemiology Network Trust (INCLEN). No single specific cause of autism has been identified but it can result from a variety of factors such as brain damage, genetic links and complications during pregnancy. Global epidemiological studies have suggested that ASD prevalence is not influenced by race or immigrant status (Fombonne, 2005). However, there is no standardised methodology to conduct epidemiological surveys, and this variability is reflected in the literature. For example, it was found that as many as one in every 38 children (2.64%) in South Korea may be diagnosed with ASD (Fombonne et al., 2016; Kim, et al. 2011).

Individuals with ASD are found to exhibit intellectual abilities varying from person to person. Iuculano et al. (2014) reported that better numerical problem solving ability was demonstrated by the children with High Functioning (HF) Autism Spectrum Disorder (ASD) when they were compared to match control group students. A study by researchers at the Stanford University School of Medicine and Lucile Packard Children's Hospital also found that children with autism and average IQs consistently demonstrated superior math skills compared with non-autistic children in the same IQ range. There appears to be a unique pattern of brain organization that underlies superior problem-solving abilities in children with autism (Menon, 2013). Chiang and Lin (2007) found that the majority of students with ASD demonstrated average mathematical ability when compared to the normal population. They also found that some individuals with AS/HF autism have mathematical giftedness.

Objectives

The students in general have a preferred way of learning, with their own individual strengths and weaknesses. There isn't one particular method to teach any learner. To teach students with autism, it is more challenging to formulate one single method since Autism Spectrum Disorder is very wide ranging. As a result, single-case research designs (SCD) are widely used in special education research, because these designs are better suited to examine the effect of individualised interventions (Horner et al., 2005). It is a challenge for both teachers and administrators to design mathematics teaching strategies that support the development of students with autism. Moreover, research on strategies for teaching mathematics to students with autism is limited (The National Research Council, 2001). It is found that students benefited from mathematics instruction or interventions which emphasises frequent feedback and explicit instructions (Butler et al., 2001).

Therefore, the purpose of this literature review is to identify mathematics interventions that present best-evidence practice for students with autism spectrum disorder.

Method and Procedure

A search procedure was undertaken to find about the studies that reported on an empirical study and the effectiveness of mathematics interventions for students with ASD.

Details of Review

The articles and papers published from 2004 till 2019 were considered. The search descriptors included the terms like mathematics, intervention, instruction, and training, or teaching method, autism, autism spectrum disorder and asperger syndrome. Recent volumes of the most well-known journals in which most of the empirical studies in the field of special education are published were hand searched namely Journal of Learning Disabilities, The Journal of Special Education, and Exceptional Children. The references lists of other recently published research syntheses were also carefully checked.

Results

Studies were finally selected based on intervention adopted for mathematics education for the students with ASD. Table 1 shows the authors, participants, setting, intervention used and outcomes /results of each study reviewed.

There were 39 participants in the reviews. The age group ranges from 4 to 19 with a mean age of 10.94. Out of which, 9 participants were females and 30 were males. The students from kindergarten to individuals attending post-secondary programs were included as participants. Intervention occurred in schools for the majority of participants. Other setting includes general education classrooms, special classroom, clinic based settings, self-contained classes, resource rooms and researcher's home.

Different types of interventions were found to be used. Out of which visual representations, cognitive strategies and technology assisted instructions were prominent. Visual representations include manipulative, pictures, number lines, and graphs of abstract concepts, functions, and relationships (X in and Jitendra, 1999). Cognitive strategies are frequently used in mathematics problem solving and are defined as a series of sequenced procedures that permit a student to complete a task effectively using rules, processes, and steps that are applied systematically to obtain a problem solution (Simpson, 2005), and include the meta-cognitive elements of when and where to apply specific strategies in the implementation and evaluation of the process and out-come (Montague, 2008; Reid and Leinemann, 2006). Technology aided instruction refers to instructions where technology is the main feature. It includes learning that occurs on computer and devices such as iPads, other tablets and specialised technology based communication devices.

Visual representation approaches were incorporated by 7 studies. Out of which, 3 studies consisted of interventions using touch point to solve mathematics problems of single and 3 digits

(Cihak and Foust, 2008; Fletcher et al., 2010; Waters and Boon, 2011). Virtual and concrete manipulative was used by one intervention (Bouck et al., 2014), and schematic diagrams was used in another intervention to solve word problems (Rockwell et al., 2011). Pointing numerals in calendar as an intervention was used in one visual representation approaches (Akmanoglu and Batu 2004). The early numeracy curriculum was used in one intervention to teach counting in sets (Jimenez and Kemmery 2013). All the studies using visual representations approaches were found to be very effective in teaching students with ASD skills of mathematics.

Technology aided instruction in the form of video self-modelling were used by three interventions (Burton et al., 2013; Hughes, E. M. 2019; Yakubova et al. 2015) to teach money estimation, acquisition and maintenance of addition, subtraction, number comparison, concepts and procedures for simplifying fractions. It was found to be effective in improvement and retention of math skills.

Cognitive strategies were implemented in 5 of the studies which includes an intervention using a high-preference strategy to increase completion of low-preference tasks (Banda and Kubina Jr., 2010). Another intervention using counting-on and next-dollar strategies (Cihak and Grim, 2008), one intervention breaking down word problems to component math skills identification of label (Levingston et al. 2009), another intervention using response-repetition as an error-correction procedure (Rapp et al., 2012) and one intervention citing specific use of cognitive or meta-cognitive strategies (Whitby, 2013). Cognitive strategy interventions were found to be successful in increasing students' mathematics skills and understanding.

Banda and Kubina Jr (2010) conducted a study to determine the relationship between math preference and mastery for five middle school students with autism spectrum disorders. Several math addition and subtraction problem formats were randomly presented to determine the students' preferences. Results indicated that preference was idiosyncratic across students. In addition, preference was not related to mastery in some students.

Cihak and Grim (2008) adopted a counting-on and next-dollar strategies to study four students with moderate intellectual disabilities and ASD. With the next-dollar strategy, students were taught to pay with one more dollar than asked for by the sales associate. This counting on method taught students to count on from the first addend to obtain the sum. Results showed that students developed and maintained independent purchasing skills, and were able to apply these skills to community settings (Cihak and Grim, 2008).

Levingston et al. (2009) strategized an intervention of breaking down word problems to component math skills identification of label, operation, larger number and smaller number to a male child with ASD in a special educational classroom. Accuracy of component skills and total solution of multiplication/ division word problems was found as the outcome of the intervention.

A cognitive strategy intervention of response repetition as an error-correction technique to increase computation of math facts was utilized by Rapp et al. (2012). Four students

diagnosed with disabilities, with two students with ASD, one with Asperger syndrome, and one with a moderate intellectual disability were included in the study. During the intervention phase, a trainer presented math problems and verbal praise for accurate answers was provided. The trainer prompted the student to verbally state the correct answer five times if the student provided an incorrect answer. It was demonstrated that response repetition was a successful cognitive strategy for three of four participants (Rapp et al., 2012).

Whitby (2013) used cognitive strategies to aid students in memorizing the steps required to complete the assigned mathematical problems successfully. It achieved the goal of teaching students accurately complete mathematic word problems by instructing them to memorize and apply *Solve It!* Problem Solving Routine's seven cognitive steps (i.e., read-paraphrase-visualize-hypothesize-estimate-compute-check). This study also required the utilization of the program's three meta-cognitive strategies that included self-management, self-questioning, and self-evaluation by the three participants with ASD. The students involved were found to solve more problems accurately than their peers during the intervention, suggesting the *Solve It!* method to be an effective strategy for teaching problem solving skills.

Discussions

The literature review found that the majority of the studies have primarily targeted basic mathematical skills. Studies of adequate quality and effective measures were found in some inferences to teach the mathematical content. The current review supports the work of Browder et al. (2008) that systematic instruction strategies effectively can be applied to teach mathematical content. There has been a concentrated effort by the centre and the state to include the children with special needs in regular schools making classroom inclusive. It leads to a growing need to teach general education curricular academics to students with ASD. A progress in demonstrating ways to teach mathematics to students with ASD is seen, although the expansion in scope of content was limited. The current review also provides support for teaching mathematics to learners with ASD by including interventions like technology-assisted instruction, use of manipulative, graphic organizers, and explicit instruction. In almost all the studies, use of treatment package that consisted of multiple methods and materials, such as a task analysis, systematic instruction, graphic organizers, and manipulative were found.

The 21st century society reflects the use of technology in all the aspects. The same is reflected in the study by the use of interventions of self modelling videos. Evidence found in technology assisted instruction may be especially beneficial for teaching mathematics to students with ASD (Burton et al. 2013; Hughes, E. M. 2019; Yakubova et al. 2015). The use of manipulative is also found to be critical to gain understanding in mathematics for students by moving from the concrete level of understanding to the abstract. With increase in instructional focus on the conceptual understanding of mathematics, manipulative become more significant. Similarly, the use of graphic organizers can help students to build conceptual understanding as well as it organizes critical information to help in problem solving. The current review found that

mathematical procedures can be task analyzed and taught using systematic prompting with feedback and evidence-based practices that were spotlighted by Browder et al. (2008).

Educating students with ASD appears to be very resource intensive because the majority of teachers require additional training in special education. Dillenberger et al. (2016) reported that teachers are not offered training in autism or appropriate interventions. Responses to their survey indicated that although all teachers (n=43) had taught children with autism, none of them had received autism training before they started working with children with this diagnosis. Teachers and educators can only ensure young learners with autism have prerequisite math skills to make progress in the general curriculum through building a strong base of early number sense. So, the teachers and the educators must be well educated and provided with additional training in special education.

The mathematics interventions can help both the teacher and the students with ASD in learning mathematics. The review also supports the effectiveness of use of explicit, systematic one-on-one interventions that target specific skill areas. Intervention procedures in the reviewed studies also recommended repeated practice and rehearsal with these specific targeted skills. Advanced concepts can be learned in a scaffold manner with modelling and guided practice. Recent reviews of mathematics interventions indicate that there is empirical support for cognitive strategies, visual strategies as well as technology assisted instructions for enhancing students' mathematic performance. The current review supports cognitive and visually based strategies for learners on the autism spectrum but additional studies are needed. So, there is need for future research to extend the literature base reviewed here.

Implications

It is found that Interventions are very helpful and effective to be used in practical situations. But, recommending one specific intervention for use across individuals is very difficult. According to the needs and level of the learners with ASD, the interventions need to be modified individually. The evidence-based practices for teaching mathematics skills such as those included in the *Early Numeracy* curriculum, including story based thematic lessons, graphic organizers, manipulative, and systematic instruction should be used (Spooner et al., 2019). Important implications for teachers, parents, policy makers and professionals can be drawn from these results.

- Teacher preparation programs and school leaders should be in tune with the needs of their teachers to support teacher development.
- Practical applications of mathematics are emphasized. Educators are encouraged to embed functional skills within mathematical learning as everyday life experiences helps learners to know when, how and why to apply their mathematical strategies.
- Strategies like cooperative learning or assistive technology can be used by a peer or special educator to make the content more accessible in a general classroom.

- Practitioners should choose evidence-based practices that match both the content and student's needs once content is selected.
- Repeated practice and rehearsal with the specific targeted skills is recommended.
- Effective use of explicit, systematic one-on-one interventions that target specific skill areas according to the needs and interests of the learner is suggested.
- Future research is recommended by taking the research gaps provided from this framework.

Conclusion

This literature review has confirmed about the growing interest in the research of mathematics education for students with ASD. More Research should be conducted to investigate about the strategies and interventions for learners with ASD with a focus that stress on the conceptual knowledge and problem solving skill. Since, there is limited number of studies related to instructional interventions in mathematics for students with ASD. Teachers should provide mathematics instruction from the earliest grades according to the needs of the students with ASD. Educational researchers should expand their investigations to apply other evidence-based mathematics interventions in settings for serving such students with special needs. It can be concluded that, learners with ASD can make gains in mathematics skills when targeted interventions are implemented.

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