The Impacts of Mathematics Instructional Strategy on Students with Autism: A Systematic Literature Review

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Abstract: Mathematics is one of the most challenging subjects for many students. A similar problem is faced by special needs students, such as students with Autism Spectrum Disorder (ASD). Various instructional strategies are implemented by specialists to help ASD students understand mathematics in schools. To explore the impacts of an instructional strategy of mathematics on ASD students, the authors conducted a review of literature from 2011 to 2017 using various databases including ProQuest Digital Dissertations and Theses Full Text, Google Scholar, and Science Direct. A total of 39 articles were found. Most of the instructional strategy aimed to assist ASD students in solving mathematics problems. The implications of the study are also discussed in this literature review, which indicates that teachers need to use the appropriate instructional strategy to meet the needs of students with ASD and maximize their mathematics learning outcomes in schools.

Keywords: Mathematics, instructional design, autism spectrum disorder, systematic literature review.


Introduction

Autism is the developmental disruption of a person's neurological system in terms of his or her social and communication skills, limited and repetitive behaviour, information processing senses, and experience of an uncommon and variety of interests when doing tasks (Autism Spectrum Disorder, 2018; Hood, 2015; Iuculano et al., 2014; Jx et al., 2017; Oie, 2016). Examples of such interruptions are language delay, lack of social interaction in the environment, unstable emotions, persistent preoccupation with objects of interest, and intellectual deficiencies (Baio et al., 2018). Often, these interruptions are not easily identified by individuals, because students diagnosed with autism spectrum disorder (ASD) can typically communicate, interact, and learn (Autism Spectrum Disorder, 2018).

Some students diagnosed with ASD develop faster than students with other types of disorder (Oie, 2016; Whitby, 2012) such as emotional disorders, intellectual disability, deafness, orthopeadic impairment, learning disabilities, traumatic brain injury, hearing loss, speech impairment, vision impairment, language impairment as well as other health impairment (Ging et al., 2018; Fchiptpunpong et al., 2019; Wright et al., 2015; Yusoff et al., 2018). The number of students diagnosed with ASD has increased by 78 per cent over the last decade, and in every 59 children, there is one child with ASD (Baio et al., 2018). Therefore, there is an urgent need for an education system with effective teaching and learning of mathematics for ASD students (Oie, 2016; Whitby, 2012; Yusaini et al., 2019), considering that half a million ASD children will enter adulthood over the next decade (Baio et al., 2018). If this need is not met, it can negatively affect the quality of ASD children in the future (Roux et al., 2013; Taylor & Mailick, 2014). Mathematics is no deemed challenging to understand for most students, but especially for ASD students, as mathematics is abstract. Appropriate teaching and learning can help ASD students overcome the problem-solving limitations that they
encounter in the learning process (Root et al., 2017; Vanmeirhaeghe, 2012). Furthermore, one way to improve ASD students’ cognitive development is by learning mathematics, which can help to organize the students’ brains (Luculano et al., 2014).

Some students diagnosed with ASD have difficulties in mathematics because learning mathematics requires a high level of cognitive ability. Moreover, having a slower understanding compared to their peers, it is difficult for them to learn complex and high-level thinking concepts (Casner, 2016; Hallahan, 2015). Students diagnosed with ASD often struggle to gain a good understanding of mathematical concepts while learning the subject (Burney, 2015). To ensure that they can understand, teachers implement repetitive ASD methods (Hallahan, 2015). However, to date, researches have shown that the teaching and learning of mathematics for students diagnosed with ASD yield a variety of outcomes (Gevarter et al., 2016; Titeca et al., 2014). Carlson et al. (2011) and Wei et al. (2013) showed that the mathematics skills and mathematics test scores of students diagnosed with ASD were lower than those of students with other disabilities.

Concrete evidence-based instruction is commonly used by teachers to overcome the constraints of learning mathematics among students diagnosed with ASD (Green, 2014)—for example, using visual supports such as numbered cards, graphic columns, graphic organizers, numbered lines, highlighted keywords and written models (Casner, 2016). With the use of visual aids, students diagnosed with ASD respond well to mathematics topics such as identification, the use of calculators, number recognition, calculations, algebra, money and geometry skills (Hughes & Casner, 2016). Students with ASD often struggle to understand concepts that involve abstract thinking. In this case, concrete evidence-based instruction can be used to help students understand these concepts. Mathematics can be taught through the use of visual aids such as visual supports such as numbered cards, graphic columns, graphic organizers, numbered lines, highlighted keywords and written models. These visual aids can help students with ASD to understand mathematical concepts.

In implementing appropriate instructional types in the learning process, teachers are always concerned to identify students with ASD students according to their learning style: visual, kinaesthetic or auditory (Meshram & Vaishnav, 2020). Choosing the right learning style, teacher attitude and school administration to manage and implement the programme can positively impact ASD learning outcomes (Mezquita-Hoyos et al., 2018; Ozen & Topal, 2019).

Methodology and Results

This section discusses the steps used in the literature review to answer a given research question. In accordance with Khan et al. (2003), five stages were applied to conduct the literature review, namely 1) developing the research question; 2) identifying articles; 3) evaluating articles’ appropriateness; 4) summarizing articles; and 5) interpreting articles’ findings.

Step I: Developing the Research Question

Developing the research question is an important step, as it forms the basis for initiating the study (Squires et al., 2013). Also, this help find and define the terms or keywords that fit the scope of the study by using databases, narrowing and refining the questions and reducing errors (Parfrey & Ravani, 2008; Squires et al., 2013). The research question for this literature review is: What were the methods of teaching mathematics to students diagnosed with ASD between the years 2011 and 2017?

Step II: Identifying Articles

This section discusses two steps to identify related articles. The first step was to identify the right keywords in the search process using the database. The keywords used were “Mathematics Instruction for Autism Students”; “Mathematics AND Autism”; “Mathematics AND Disorder”; “Mathematics AND Disability”; and “Mathematics AND Students with ASD”. The databases used in this literature review are a) ProQuest Digital Dissertations and Theses Full Text, b) Google Scholar and c) ScienceDirect. The search was limited to articles published between 2011 and 2017. The second step was to search for the articles, which resulted in 49,800 articles (ProQuest: n = 37,900; Google Scholar: n = 11,186; ScienceDirect: n = 714). It was found that not all of the articles met the topics required in this study. Therefore, the second round of the search was conducted, which resulted in a total of 52 articles. The final step was to review the articles in depth.

It was found that only 39 articles met the criteria. All articles were theses, dissertations and journal articles. The eligibility criteria that constituted inclusion in this review were: (a) published on a valid database; b) involved students at the preschool, primary and secondary levels; c) involved students diagnosed with ASD; d) experimental research design; e) reporting teaching and learning applied by teachers in teaching mathematics; and f) published in English.
A total of 13 articles were excluded, eight for having a non-experimental research design (i.e., Carlson et al., 2011; Hood, 2015; Judge & Watson, 2011; Morgan et al., 2011; Schulte & Stevens, 2015; Stevens et al., 2015; Wei et al., 2013; Whitby, 2012), one for not involving ASD students (i.e., Praet et al., 2013), and four for being literature reviews (i.e., Kim & Cameron, 2016; Klaren et al., 2017; Powell et al., 2013; Su et al., 2012).

**Step III: Evaluating Articles**

Inclusion and exclusion criteria were set and established to evaluate the suitability of the articles for this literature review. Both requirements were intended to act as feedbacks to achieve the objectives of the review. In addition, the aim of setting the criteria was to optimize the external and internal validity of the studies. The most critical aspect in evaluating individual article always refers to "what methods are used by the teachers in teaching mathematics to students diagnosed with ASD." This literature review is based on a recent study by Hord and Bouck (2012), who asked what kind of academic instruction in mathematics was used to teach students diagnosed with mild intellectual disability (MID) in the last 11 years. The conclusions drawn from the findings of Hord and Bouck (2012) suggested that a majority of teachers were concerned with the planning of mathematics teaching interventions to improve computational procedures, knowledge of mathematical facts, and mathematical problem-solving. Some of the interventions implemented by teachers were 1) using flashcards, 2) using traditional algorithms, and 3) using technology. In addition, Desoete et al. (2013) and Praet et al. (2013) suggested that teachers’ knowledge plays a significant role in determining the method of intervention or type of instruction in the teaching and learning of mathematics to address the needs of students with disabilities.

**Step IV: Summarizing Articles**

The researcher summarized the related articles to answer the research question (Oxman et al., 2002). As stated in step II, the articles used in this study underwent several screening steps based on the determined criteria until only 39 articles remained. A total of 13 articles were excluded because they did not meet the criteria of this study. The articles were all relevant to the topic to be discussed in this literature review, mathematical instruction for autistic students. Galvan and Galvan (2017) encouraged the development of a table that would assist researchers in compiling, summarizing and concluding articles that are in line with the literature review. Table 1 below details the articles used in this literature review.

**Table 1. Source of selected articles**

<table>
<thead>
<tr>
<th>Database</th>
<th>N</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Scholar</td>
<td>39</td>
<td>29</td>
</tr>
<tr>
<td>ProQuest Digital Dissertations and Theses Full Text</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Science Direct</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>39</td>
</tr>
</tbody>
</table>

**Step V: Interpreting Findings**

A total of 39 articles were included based on the inclusion and exclusion criteria. The next step was to perform the coding process based on the information obtained from the study. The purpose of the coding process is to examine the mathematics instructions used during the seven-year period under study. Codes were given according to the characteristics of the study—e.g., author, number of participants, study area, instructional strategy, study design, teaching duration. A summary of the research findings is given in Appendix A. Data in Appendix A present the specific instructional strategies implemented by teachers during the teaching and learning of mathematics. The application of instructional strategies was based on students with different ASD learning styles, which are categorized as visual (V), kinaesthetic (K), auditory (A) or a combination of VKA. The analysis showed that teachers more often implement visual teaching styles than kinaesthetic, auditory or VKA styles. Twenty-two empirical studies apply visual teaching styles, such as (a) concrete-representational-abstract; (b) mathematical word problem-solving interventions; (c) non-symbolic and symbolic number word; (d) schematic approach; (e) writing equations on paper; (f) real-life problems; (g) using materials that are both concrete (physical objects) and virtual (3-D objects on the computer); (h) video modelling package based on iPad; (i) number line mapping; (j) strategic schema-based instruction; (k) modified schema-based instruction; (l) flash cards; (m) numerical competencies; (n) mathematics based on conceptual approach; (o) the role of specific symbolic difference; (p) special cognitive criteria; (q) e-book education; (r) executive functioning; (s) computer-aided instruction; (t) interactive whiteboard and discrete trial training; (u) mathematical facts mastery; and (v) metacognitive, based on the computer. Interestingly, SBI is the most frequently used instructional strategy (Aagten-Murphy et al., 2015; Bae, 2013; Bae et al., 2015; Bouck et al., 2014; Burney, 2015; Casner, 2016; Cox & Root, 2018; Cravalho et al., 2014; Delisio et al., 2018; Desoete, 2012; Fries, 2013; Göransson, 2016; Hansen, 2014; Henning, 2018; Hiniker, 2016; Jowett et al., 2012; Kasap & Ergenekon, 2017; Maajeeny, 2017; Maras et al., 2017;
The remaining 11 studies integrated either A, K or a combination of several teaching styles. Only five empirical studies in Appendix A implemented instructional strategies based on kinaesthetic learning: for example, (a) self and match, (b) hand technique and manipulation, (c) mathematical cognition, (d) mathematics recovery programme and (e) functional magnetic resonance imaging (Croce, 2015; Geary et al., 2012; Iuculano et al., 2014; Tzanakaki et al., 2014; Vitalo, 2017). Another three studies used instructional strategies based on auditory learning styles such as (a) mathematics instruction based on stories with systematic instruction; (b) metacognitive monitoring (one-on-one); and (c) storybooks (Brosnan et al., 2016; Green, 2014; Jimenez & Kemmery, 2013). The final three studies utilizing a combination of several instructional strategies, namely (a) clinical and cognitive criteria, (b) mathematical problem-solving, and (c) the multi-component approach (Alter, 2011; Oswald et al., 2016; Titeca et al., 2015).

Discussion

The majority of the researchers designed learning methods for students diagnosed with ASD based on the data from formative and summative assessments to identify the needs of the students in the teaching and learning process before a learning plan was created (Forbringer & Fuchs, 2014; Hagaman et al., 2013). Students who succeed in studying mathematics possess two types of knowledge: (a) conceptual understanding and (b) procedural skills (Rittle-Johnson, 2017). Conceptual understanding is a student’s ability to understand the principles of mathematics or the relationship underlying the targeted concepts (Rittle-Johnson & Schneider, 2015). However, conceptual understanding is one of the most challenging aspects for students diagnosed with ASD to achieve, because they have impaired functional skills (Happe et al., 2006), making it difficult to grasp the multidimensional relationships that require knowledge of many mathematics concepts (Rittle-Johnson & Schneider, 2015). For example, when teaching fractions to students diagnosed with ASD, teachers must be able to relate previous knowledge of the whole number and use concrete models to scaffold knowledge construction.

Meanwhile, procedural skills denote the ability of students to identify which procedure needs to be used to find the right answer (Rittle-Johnson & Schneider, 2015). The most challenging problem for students diagnosed with ASD is the difficulty they face when translating mathematical forms into mathematical concepts and applying them to solve mathematical problems (Root et al., 2017). By emphasizing high conceptual and procedural understanding, students diagnosed with ASD will be able to use the knowledge they have to solve mathematical problems (Common Core State Standards Initiative, 2014; Griffin et al., 2013; Rockwell et al., 2011).

The results show that students with ASD are poor at understanding new information and procedural computation (Gomot & Wicker, 2012; Maes et al., 2011). Thus, we need to change our perception that there is a need for an instructional strategy that emphasizes student engagement, building own knowledge, discussion, exploration, communication and working in groups (Griffin et al., 2013). In the 39 articles obtained, the most frequent method used by researchers was the schema-based method, as studied by Bae (2013), Casner (2016), Cox and Root (2018), Delisio et al. (2018), Kasap and Ergenekon (2017), Rockwell (2012), Rockwell et al. (2011) and Root et al. (2017, 2018). The schematic strategy emphasizes the grasp of procedural concepts and step-by-step skills, aided by visual representations in the form of images or diagrams, and numerical equations which are suitable to solve the problem (Fang et al., 2015; Jitendra & Star, 2011). In addition, this strategy emphasizes computational skills (addition and subtraction) and problem-solving (Forbringer & Fuchs, 2014; Rockwell, 2012). The modified schema strategy focuses on three aspects of instruction: 1) the technique of solving problems in writing and pairing them with pictures; b) every image being colour-coded or coded with the main criteria from the type of problem (concrete scheme); and c) clearly and systematically emphasizing each step of the question so that the students can understand in more depth the concept of the knowledge and the procedural skills (Root et al., 2017). This strategy has assisted ASD students in computational problems, solving mathematical problems, and improving their cognitive abilities (Rockwell et al., 2011; Spooner et al., 2017). Meanwhile, the second method is computer-based (iPad-based video modelling, physical objects and 3-D virtual objects). This method is based on conceptual approaches (symbolic numbers, flashcards, CRAs, and real-life problems).

Conclusion

Instructional strategies implemented by teachers are one way to improve the quality of teaching in schools, especially for students with ASD. Many studies have called for a change in the way teachers teach mathematics as a subject in schools and have encouraged comparisons with instructional strategies used globally. Effective mathematics-based methods have a positive impact on ASD students’ skills in solving mathematical problems. Therefore, teachers should use instructional strategies to meet the needs of students to maximize their learning outcomes in schools.

Recommendation
Based on the findings, it is recommended that other researchers further identify teachers applying instructional strategies based on (a) the type of learning style, (b) age, (c) gender, and (d) family background of each study, and (d) analyse the interaction between these variables.

**Limitations**

There are several limitations to this study. The article search process was based on particular keywords, so the researcher only obtained a few articles. Moreover, the researcher set appropriate article criteria for analysis in this study so that the citation information obtained was more limited. The databases used in this study were ProQuest Digital Dissertations and Theses Full Text, Google Scholar and ScienceDirect. The most cited database is Google Scholar. Future studies need to find and use more diverse databases with a longer duration.

**Acknowledgement**

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**References**

*References marked with an asterisk indicate studies included in the systematic literature review.*


### Appendix A. The details of the 39 studies included in the systematic literature review

<table>
<thead>
<tr>
<th>Author</th>
<th>n</th>
<th>Setting</th>
<th>Instructional Strategy</th>
<th>Design</th>
<th>Length of instruction</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aagten-Murphy et al. (2015)</td>
<td>32</td>
<td>London</td>
<td>Symbolic, Non-symbolic and number line mapping</td>
<td>Experiment</td>
<td>During instruction</td>
<td>The symbolic use and numerical mapping method can increase the proficiency of ASD students</td>
</tr>
<tr>
<td>Alter et al. (2011)</td>
<td>3</td>
<td>Primary School (Midwester n)</td>
<td>Mathematical problem-solving (PMM)</td>
<td>A multiple-baseline across participants design</td>
<td>15 minutes</td>
<td>The study supports the use of PMM interventions to improve students' mathematical problem-solving skills</td>
</tr>
<tr>
<td>Bae (2013)</td>
<td>40</td>
<td>Primary School (New York State)</td>
<td>Schematic Approach</td>
<td>Mixed method</td>
<td>30-40 minutes/session</td>
<td>There is a remarkable improvement in the achievements of ASD students regarding problem-solving and mathematics knowledge</td>
</tr>
<tr>
<td>Bae et al. (2015)</td>
<td>20</td>
<td>Public School (US)</td>
<td>Real-life problems</td>
<td>Quantitative</td>
<td>30-45 minutes for 3 weeks</td>
<td>The real-life problems method can improve ASD students' problem-solving abilities</td>
</tr>
<tr>
<td>Bouck et al. (2014)</td>
<td>3</td>
<td>Autism Clinic</td>
<td>Using concrete materials (physical objects) and virtual (3-D objects in computer)</td>
<td>Single subject</td>
<td>1 year</td>
<td>Applying concrete material methods (physical objects) and virtual (3-D objects in a computer) can increase the ASD student's abilities in solving problems</td>
</tr>
<tr>
<td>Brosnan et al. (2016)</td>
<td>56</td>
<td>Classroom (UK)</td>
<td>Metacognitive monitoring</td>
<td>Experiment</td>
<td>Based on UK curriculum</td>
<td>Metacognitive monitoring can support learning for ASD students</td>
</tr>
<tr>
<td>Burney (2015)</td>
<td>3</td>
<td>Secondary School Bandar (United States of America)</td>
<td>Concrete-Representational-Abstract (CRA) and Multiple Baseline Design (computer-assisted)</td>
<td>Multiple Baseline A-B (pre-test/post-test)</td>
<td>30 minutes every week</td>
<td>Findings show that using concrete-representation-abstract (CRA) teaching and explicit direction can improve ASD students' achievement in mathematics</td>
</tr>
<tr>
<td>Casner (2016)</td>
<td>21</td>
<td>Primary School (Midwest)</td>
<td>Schematic instruction</td>
<td>Mixed method</td>
<td>School year 2013-2014</td>
<td>Schematic-based instruction can improve students' mathematical problem-solving skills</td>
</tr>
<tr>
<td>Cox &amp; Root (2018)</td>
<td>2</td>
<td>Home (United States of America)</td>
<td>MSBI with provided visual supports</td>
<td>A single-case ABAB</td>
<td>2 or 3 times a week</td>
<td>MSBI strategy could solve mathematical problems of ASD students</td>
</tr>
<tr>
<td>Author</td>
<td>n</td>
<td>Setting</td>
<td>Instructional Strategy</td>
<td>Design</td>
<td>Length of instruction</td>
<td>Summary</td>
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<tr>
<td>Cravalho, et al. (2014)</td>
<td>3</td>
<td>Primary School (Pacific)</td>
<td>Flash cards</td>
<td>A multiple baseline design across number/fact groups and participants</td>
<td>1 and 3 days a week</td>
<td>Flashcard intervention is effective towards the teaching of number correspondence and interpretation</td>
</tr>
<tr>
<td>Croce (2015)</td>
<td>7</td>
<td>Classroom (US)</td>
<td>Self &amp; Match</td>
<td>Experimental</td>
<td>30 minutes, (1 time per weeks)</td>
<td>The Self &amp; Match method is effective in increasing the behaviour of ASD students in the classroom</td>
</tr>
<tr>
<td>Delisio et al. (2018)</td>
<td>3</td>
<td>Classroom (Florida)</td>
<td>1) Mathematical Word Problem Solving Interventions 2) SBI 3) The K-N-W-S graphic organizer 4) Video Modelling</td>
<td>A quasi-experimental</td>
<td>Six sessions</td>
<td>There is an increase in mathematics learning</td>
</tr>
<tr>
<td>Desoete et al. (2012)</td>
<td>16</td>
<td>Preschool (Belgium)</td>
<td>Non-symbolic and symbolic (number word (NW) and Arabic number (AN))</td>
<td>Comparison</td>
<td>Short version</td>
<td>There is a NW relationship in increasing students’ achievement in arithmetic subjects</td>
</tr>
<tr>
<td>Fries (2013)</td>
<td>4</td>
<td>Primary School (US)</td>
<td>MMF (Mathematical Facts Mastery)</td>
<td>A single case</td>
<td>30-minutes every day-40 days/8 weeks</td>
<td>The MMF method was effective towards the students’ skills in solving the problem of basic subtraction, adding and mixed subtraction</td>
</tr>
<tr>
<td>Geary et al. (2012)</td>
<td>16</td>
<td>Primary School (US)</td>
<td>Mathematical cognition</td>
<td>Experiment</td>
<td>Based on mathematics curriculum when the children are starting the research 735 minutes</td>
<td>Mathematical cognition is a very important aspect and contributes to the difference in individual and group performances for the starting point of numerical operations</td>
</tr>
<tr>
<td>Göransson et al. (2016)</td>
<td>60</td>
<td>Classroom (Swedish)</td>
<td>Mathematics based on conceptual approach</td>
<td>A qualitative content analysis</td>
<td>20 minutes / 3 days (6 weeks)</td>
<td>This strategy effects students so that they be involved in the learning process individually or in group</td>
</tr>
<tr>
<td>Green (2014)</td>
<td>50</td>
<td>Preschool (US)</td>
<td>Storybook</td>
<td>Quasi-experimental group design</td>
<td>20 minutes / 3 days (6 weeks)</td>
<td>This method can help the cognitive development of students</td>
</tr>
<tr>
<td>Author</td>
<td>n</td>
<td>Setting</td>
<td>Instructional Strategy</td>
<td>Design</td>
<td>Length of instruction</td>
<td>Summary</td>
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<tr>
<td>Hansen (2014)</td>
<td>8</td>
<td>Primary School (US)</td>
<td>Mathematics courseware Computer-aided instruction (CAI)/ TeachTown software</td>
<td>Mixed method</td>
<td>15 weeks</td>
<td>The method of mathematics application (computer-assisted instruction (CAI) was effective for students' academic achievement</td>
</tr>
<tr>
<td>Henning (2018)</td>
<td>3</td>
<td>Classroom (US)</td>
<td>Number of conversations with support The Role of Specific Symbolic Difference</td>
<td>Experiment</td>
<td>5-18 sessions</td>
<td>This method can improve the ENS skills of ASD students Symbolic systems may help ASD students to give inaccurate information.</td>
</tr>
<tr>
<td>Hiniker et al. (2016)</td>
<td>36</td>
<td>Living Room (San Francisco) Autism Clinic (US)</td>
<td>Functional magnetic resonance imaging (fMRI)</td>
<td>Experiment</td>
<td>500-1500 minutes</td>
<td>Symbolic systems may help ASD students to give inaccurate information.</td>
</tr>
<tr>
<td>Iuculano et al. (2014)</td>
<td>18</td>
<td>Autism Clinic (US)</td>
<td>Functional magnetic resonance imaging (fMRI)</td>
<td>Experiment</td>
<td>6 minutes 36 seconds for every task</td>
<td>The method of fMRI activation can help increase the ability of ASD students to solve number problems independently</td>
</tr>
<tr>
<td>Jimenez &amp; Kemmery (2013)</td>
<td>5</td>
<td>Classroom (Carolina)</td>
<td>Mathematics instruction based on stories with systematic instruction</td>
<td>Experimental</td>
<td>4 months</td>
<td>Increasing proficiency and deeper knowledge relating to mathematics</td>
</tr>
<tr>
<td>Jowett et al. (2012)</td>
<td>1</td>
<td>Living Room</td>
<td>VM package based on iPad</td>
<td>A single-subject, multiple baseline across-tasks</td>
<td>6 weeks</td>
<td>The VM Package based on iPad method was effective to increase the ASD students' proficiency in calculating</td>
</tr>
<tr>
<td>Kasap &amp; Ergenekon (2017)</td>
<td>3</td>
<td>Home (Turkey)</td>
<td>Schematic Approach</td>
<td>A single-subject, multiple-probe design</td>
<td>1-5 weeks</td>
<td>The schematic approach is effective in teaching ASD students to solve mathematics problems</td>
</tr>
<tr>
<td>Maajeeny (2017)</td>
<td>4</td>
<td>Classroom (Atlantic)</td>
<td>Interactive whiteboard (IAW) and discrete trial training (DTT)</td>
<td>Experimental design &amp; a single case design (SCD)</td>
<td>5-10 minutes</td>
<td>There were IAW and DTT effectiveness towards the ASD students' initial computational skills</td>
</tr>
<tr>
<td>Maras et al. (2017)</td>
<td>40</td>
<td>Secondary School (England)</td>
<td>Metacognitive based on computer</td>
<td>Comparison</td>
<td>For subjects taught in school suitable with the curriculum</td>
<td>The “metacognitive” approach can improve ASD students' mathematical achievements</td>
</tr>
<tr>
<td>Oie (2016)</td>
<td>6</td>
<td>Primary School (Tokyo)</td>
<td>Writing equations on paper</td>
<td>Observation</td>
<td>1 hours at instruction opening</td>
<td>Writing the calculations on paper could help students to achieve correct answers</td>
</tr>
<tr>
<td>Oswald et al. (2016)</td>
<td>27</td>
<td>Secondary School (California)</td>
<td>Clinical and Cognitive Criteria</td>
<td>Experiment</td>
<td>48 hours</td>
<td>The results revealed that the most powerful predictor in solving mathematics problems was reasoning</td>
</tr>
</tbody>
</table>
### Appendix A. Continued

<table>
<thead>
<tr>
<th>Author</th>
<th>n</th>
<th>Setting</th>
<th>Instructional Strategy</th>
<th>Design</th>
<th>Length of instruction</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rasmussen &amp; Bisanz (2011)</td>
<td>21</td>
<td>Primary School (Canada)</td>
<td>Special cognitive criteria</td>
<td>Experiment</td>
<td>1.5 hours</td>
<td>Teaching methods based on cognitive skills can improve ASD students' mathematics achievement</td>
</tr>
<tr>
<td>Rockwell et al. (2011)</td>
<td>1</td>
<td>Room at Home (US)</td>
<td>Strategic schema-based instruction (SBI)</td>
<td>A multiple-probes across behaviours single-case</td>
<td>2 hours 45 minutes (8 weeks)</td>
<td>The SBI method is effective for solving the problems of addition and subtraction among ASD students</td>
</tr>
<tr>
<td>Rockwell (2012)</td>
<td>2</td>
<td>Home (Dining Room)</td>
<td>Strategic schema-based instruction (SBI)</td>
<td>A multiple-probes across behaviours single-case</td>
<td>30-min (Monday to Friday)/ during summer holiday</td>
<td>The SBI method improves the achievement of solving problems among ASD students</td>
</tr>
<tr>
<td>Root et al. (2017)</td>
<td>3</td>
<td>Primary School (US)</td>
<td>Modified schema-based instruction (MBSI)</td>
<td>A multiple probe across participants</td>
<td>15-20 minutes</td>
<td>Instructions based on modified scheme can improve performance in solving mathematical problems among students</td>
</tr>
<tr>
<td>Root et al. (2018)</td>
<td>3</td>
<td>Primary School (US)</td>
<td>Modified schema-based instruction (MSBI)</td>
<td>A multiple probe across participants design</td>
<td>4 days a week</td>
<td>MBSI method could improve student’s method to analyse task independently</td>
</tr>
<tr>
<td>Shamir &amp; Baruch (2012)</td>
<td>52</td>
<td>Primary School (Israel)</td>
<td>E-book education</td>
<td>Experiment</td>
<td>30 minutes</td>
<td>E-book education is recovering vocabulary skills and early mathematical skills of students</td>
</tr>
<tr>
<td>Titeca et al. (2014)</td>
<td>27</td>
<td>Primary School (US)</td>
<td>Numerical competencies (vs, c, mc,e, ao)</td>
<td>Experiment</td>
<td>Final year of preschool</td>
<td>The numerical performance method is the foundation for the development of ASD students' mathematical knowledge</td>
</tr>
<tr>
<td>Titeca et al. (2015)</td>
<td>121</td>
<td>Primary School</td>
<td>Multi-component approach</td>
<td>Quantitative</td>
<td>50 minutes</td>
<td>There is strength, mathematical ability among students by stressing on the importance of other mathematics field</td>
</tr>
<tr>
<td>Toll et al. (2011)</td>
<td>227</td>
<td>Secondary School</td>
<td>Executive functioning</td>
<td>Comparison</td>
<td>30 minutes</td>
<td>Benefits of executive functioning to predict the future achievement of students and target students with low scores to continue to perform in mathematics</td>
</tr>
<tr>
<td>Tzanakaki et al. (2014)</td>
<td>24</td>
<td>Primary School (UK)</td>
<td>Mathematics recovery program</td>
<td>Experiment</td>
<td>12 weeks (3 hours 30 minutes until 10 hours 20 minutes)</td>
<td>Mathematical recovery can improve to students’ calculation ability</td>
</tr>
<tr>
<td>Vitalo (2017)</td>
<td>4</td>
<td>Primary School (US)</td>
<td>Hand technique and manipulation, CRA instructional</td>
<td>Mixed method</td>
<td>30 minutes</td>
<td>Techniques and manipulation of hand and instructional CRA showed remarkable improvement in learning outcomes, student engagement and positive impressions on student attitudes in learning mathematics</td>
</tr>
</tbody>
</table>