An Updated Evidence-based Practice Review on Teaching Mathematics to Students with Intellectual Disabilities

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Summary
Educational programs for students with intellectual disabilities have undergone drastic changes in pursuit of the general curriculum. Accordingly, teachers in various fields, including mathematics, strive to find effective methods that enhance learning. The objective of this systematic review is to examine the field of teaching mathematics to students with intellectual disabilities to investigate relevant effective teaching strategies and required teaching skills. To achieve this goal, studies published during the period 2018-2021 were reviewed. Findings indicate the inclusion of nine studies that met the inclusion criteria out of 55 studies. The included studies found that the system of least prompts (SLP) in conjunction with feedback and error correction, and schema-based instruction are generally the most effective strategies in teaching mathematical skills to students with intellectual disabilities. Addition is the most targeted skill, followed by subtraction and algebra problem solving. The least targeted skills are multiplication, recognition of geometric shapes, calculating price after discount, rapid recognition of numbers, and rapid problem solving. The paper provides recommendations and suggests venues of future research.
Keywords: *strategies; skills; teaching; mathematics; intellectual disability*

1. Introduction

High-quality education for students with disabilities, including intellectual disabilities, has steadfastly been of primary interest to researchers and practitioners since the enaction of the No Child Left Behind Act, 2001, and other relevant legislations such as (Every Student Succeed Act, 2015), and the approval of Individuals with Disabilities Education Act Education (IDEA) (Spooner et al., 2019). IDEA (2004) stipulates that all students with disabilities shall participate and progress in general education curricula, including mathematics (Bowman et al., 2019). Mathematics is an important subject that affects many aspects of the life of students with disabilities, including employment, financial skills, and purchasing (Park et al., 2020)). It is also associated with quality of life when transitioning to post-school life (Bouck et al., 2018).
However, students with intellectual disabilities tend to face much greater challenges in mathematics than ordinary students (Park et al., 2020). This is owing to the fact that these individuals experience intellectual and adaptive performance deficits that affect conceptual, social, and practical domains (American Association on Intellectual and Developmental Disabilities [AAIDD], 2013). Kearns et al. (2011) found that less than 50% of students with developmental disabilities were able to solve problems requiring basic arithmetic skills with or without a calculator. A large number of students with intellectual disabilities face difficulties in learning mathematics because it requires abstract thinking, reasoning, understanding, and communication. This greatly affects students' academic performance in mathematics (Taylor et al., 2005). Several studies have indicated that people with intellectual disabilities have difficulty solving arithmetic problems. Such skills constitute a difficult and complex process for them (Ozsoy et al., 2015).
Gray (2014) points that student have difficulty perceiving spatial relationships, distances, and the order of elements in a logical sequence. Kumatongo (2019) points out time perception difficulties such as telling time, keeping track of time, and estimating time, as well as difficulties in understanding financial values such as monetary concepts, and counting money. In addition, students with intellectual disabilities face difficulties with abstract mathematical symbols and tend to confuse symbols such as +, -, x, <, =, >, %, 7, 8, 6, 2 (Geary, 2014; Hord & Xin, 2015). Moreover, they face challenges related to the facts of numbers, recalling the answer, and recognizing the correct solution strategy, as in answering 2 + 2, 3 + 2, or 3-1. Accordingly, they have trouble adding and subtracting numbers (Kumatongo, 2019). However, several studies have shown that students with intellectual disabilities can learn arithmetic skills such as identifying numbers, forming groups, marking, and counting skills, such as rote counting, but they need clear strategies and frequent opportunities for practice (Jimenez & Saunders, 2019; Spooner et al., 2019; Bowman et al., 2019.) Students with moderate and severe disabilities can acquire a wide range of academic mathematical skills when they are given clear instructions (Bowman et al., 2019). Different mathematical challenges and individual differences in mathematical conceptual knowledge may be due to a lack of exposure to educational experiences or a lack of effective instructional strategies (Jordan et al., 2009; Purpura et al., 2011). Therefore, to acquire basic mathematical skills, students with intellectual disabilities urgently need special educational strategies (Agodini, et al., 2010).
Given the importance of the topic, there is much divergence

Manuscript received May 5, 2022
Manuscript revised May 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.5.36

among studies on determining the methods or materials, and strategies of teaching mathematics, as well as the key skills taught, to students with intellectual disabilities, autism, and developmental disabilities. In a meta-analysis carried out by Browder et al. (2008), of a set of 86 experimental studies on teaching mathematics to individuals with cognitive disabilities, findings indicate that most studies dealt with numbers and arithmetic or measurement skills. In specific arithmetic studies, skills mostly focused on counting, arithmetic, or matching numbers, while almost all measurement studies focused on financial skills. These studies also provide strong evidence of the use of structured teaching to teach mathematical skills, community-based teaching, prompting and fading, constant time delay, and SLD.

This was followed by a systematic review by Hudson et al. (2018), in which they pointed out that since the review of Broward et al. was conducted, a literature review incorporated additional 29 studies. It was shown that the studies dealt with skills (counting and operations, geometry, algebra, measurement, and data analysis). This systematic review also found evidence in support of employing direct teaching, SLP, constant time delay strategy, and task analysis as evidence-based practices of teaching mathematics to students with severe cognitive disabilities.

Bowman et al. (2019) conducted a systematic review intended to provide an update of the research on teaching mathematics to students with moderate and severe disabilities, published between 2005 and 2017. Findings of the 29 studies covered by the review showed that 75% of studies focused on number and problem-solving skills, while the remaining 25% dealt with measurement, algebra and geometry. This indicates that researchers are beginning to expand the scope of mathematics contents. Strategies included the use of the Concrete-Representational-Abstract (CRA) instructional strategy, schema-based instruction, and educational technology.

In their most recent systematic review, Park et al. (2020) focused on acquiring and maintaining mathematical skills. The researchers reviewed all studies from 1975 to 2018 that dealt with teaching mathematics to students with intellectual disabilities. Twenty-two studies were included in the final analysis. There was no consensus among researchers on procedural criteria of the maintenance phase. In studies that covered the maintenance phase, numbers and problems were the most taught mathematical contents. All studies used intervention packages that included more than one strategy or educational material. The most used strategy was SLP, while the most used educational materials were visual supports and tactile aids. Findings also suggest the use of several evidence-based practices, such as explicit instruction, time delay, feedback, and Virtual-Representational-Abstract (VRA) teaching.

The above systematic reviews suggest the use of several emerging and evidence-based practices such as VRA sequence, which is an improvement of the CRA sequence traditional approach, in which the first tactile stage was replaced with a virtual one utilizing web-based applications through electronic devices. The other two phases remained unchanged. In the representational stage, students use symbols and dots to express numbers, while in the abstract stage no aids are used (Bouck et al., 2018). Another emerging practice is the use of schema-based instruction (SBI), which involves visualization of mathematical relationships through diagrams, problem solving through explicit teaching, and the teaching of metacognitive strategies to help students observe the problem-solving process (Root at al., 2019). Research has also revealed several emerging evidence-based practices, such as the Understand and Solve! Strategy, which aims at the seven-step cognition (i.e. reading, paraphrasing, imagining, hypothesizing, predicting, calculating, and verifying). Each step of the cognitive strategy includes the three metacognitive steps: ask, say, and verify (Daniel, 2003; Karabulut, & Özmen, 2018).

As research on technology and mathematics for students with intellectual disabilities advances rapidly (Ehsan et al., 2018), the objective of the current review is to provide an update of research on strategies of teaching mathematics to students with intellectual disabilities during the period 2018-2021. The review seeks to identify strategies of teaching mathematics to students with intellectual disabilities, and the mathematical skills focused on in research, and to determine the effectiveness of those strategies in imparting mathematical skills to students with intellectual disabilities. The key questions are:

1. What strategies are used in teaching mathematics to students with intellectual disabilities?
2. What mathematical skills are taught to students with intellectual disabilities?
3. To what extent are the strategies employed in imparting mathematical skills to students with intellectual disabilities effective?

and the study also provides a new evaluation to analyze the outputs of the scientific publishing of the Web of Science and the SCOPUS database.

2. Methodology

The systematic review protocol was developed using some systematic review guides such as Newman and Gough (2020), which is a new guide for conducting systematic reviews in educational research, and the PRISMA Handbook (Moher et al., 2009). Based on these guides, a set of rules for the selection of studies was developed.

3.Inclusion and exclusion criteria

Inclusion and exclusion criteria are defined in the selection process. Selection criteria include the following:

Only single-case studies in English were included. Study should be meant as an intervention to improve mathematical skills. At least more than half of the participants in the studies are students diagnosed with intellectual disabilities. Studies in the field of elementary, intermediate and secondary education shall be included. Studies shall focus exclusively on mathematical skills. Included studies shall be controlled and were published between the period of 2018-2021. Master's and doctoral theses, books, reviews, conference papers, and other publications that do not meet the above criteria were excluded.

3. Search and Selection Strategy

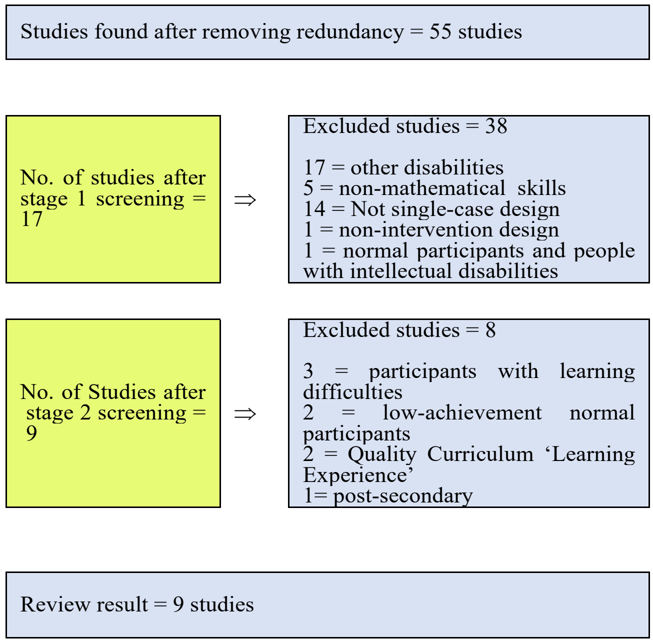
To identify the studies eligible for inclusion in the review, the researcher conducted an electronic systematic search for studies in English published during the three-year period from January 01, 2018 to January 01, 2021 in the following databases: (ProQuest, EPSCO, Google Scholar, Scops, Web of science). The search process was conducted in English using words related to the three categories of disability, skills, and mathematics instructional strategies, as shown in Table (1).All references in the studies included in this systematic review were manually searched, and the search yielded no additional results.

Table1: Search Terms Used in the Online Database Search

Item	Search words
Disability	intellectual impairment intellectual disabilit* intellectual dysfunction developmental disability* intellectual developmental disorder mental deficiency mental* retard* mental* handicap* mental* disab* mental insufficiency mental* impair* mental*
Mathematics teaching skills	add*, subtract*, multiply,* divide, division, money, time, probability, graph*, count,* math*, numbers, operations, geometry, algebra, data analysis, probability, and measurement
Mathematics teaching Strategies	strategy, intervention, evidence-based practice, program, teaching, training

Studies identified by pre-selected words in the search process were subjected to a two-stage screening to ensure that they met the inclusion and exclusion criteria. In the first stage, titles and abstracts were examined to determine the relevance of a study, while in the second stage studies were fully examined. The initial search resulted in 55 studies. After reading the titles and abstracts in the first stage, 38 studies that did not meet the criteria were excluded (Appendix 1). In the second stage, 17 studies were selected, and each study was reviewed in full to verify that it met the inclusion criteria. Another 6 studies that did not meet the criteria were excluded (Appendix 2). Accordingly, 9 studies that were considered eligible for the result of this current review were obtained. The review process is also summarized in a PRISMA diagram (Fig. 1), which shows the sequence of these stages, and the reasons for the exclusion of studies.

Table 2 : Key characteristics of included studies.



5.Data extraction and synthesis

Data were extracted using an extraction table that identifies the year, author, study objective, strategy, targeted skill, participants (number, gender, age, disability diagnosis and level, and study stage), single-case research design, and effectiveness of strategies, as shown in Table (2).

Table 2: Key characteristics of included studies.

No	Author & Year	Objective	Strategy	Targeted Skill	Participants	Design	Strategy Effectiveness
1	Karabulut, & Özmen, (2018)	Effectiveness of the Understand and Solve! Strategy in addition and subtraction problems learners with intellectual disabilities (LID) contexts, and the extent of maintaining the skill after intervention, ability to generalize about different types of problems and two-digit problems, as well as recognizing students' attitudes towards strategy and controlling the use of strategy.	Understand and Solve! Strategy	Solving one-digit addition and subtraction problems	Three students with mild intellectual disability, two females and one male, aged 11-12. Intermediate stag	Multi-probe across subjects	The understand and Solve! Strategy was effective in teaching students with mild intellectual disabilities to solve single-digit addition and subtraction problems. They maintained their skills and were able to generalize them in new two-digit addition and subtraction problems. As a result of this intervention, students' attitudes to problems were changed. They were also able to use and control the strategy to solve problems.
2	Browder et al . (2018)	Assessment of a modified schema-based multi-instruction intervention that includes task analysis, graphic organizers, self-monitoring, and concrete methods of problem-solving instruction for students with intellectual disabilities	modified schema-based instruction that embedded effective practices (pictorial task analysis, graphic organizers, systematic prompting with feedback)	Solving oral addition and subtraction problems, and distinguishing between different types of problems.	Eight students, five females and three males with moderate intellectual disabilities, aged 10-13. Elementary and intermediate stages	Multi-probe across participants	There is a functional relationship between MSBI and the number of steps taken independently and correctly to solve verbal problems, and also distinguishing between problem solving and problem type. All students showed steady progress in problem solving and distinguishing between addition and subtraction problems, as well as ability to generalize these skills.
3	Bouck et al., (2018)	Determining the extent of improvement of students with mild intellectual disabilities in their mathematical skills through VRA and ability to maintain their performance in solving mathematical problems, and eliciting their	virtual–representational–abstract (VRA)	Place value, addition with regrouping, subtraction with regrouping, one-digit multiplication.	Two male students with mild intellectual disabilities, their ages ranged between 12-13 High school	Multi-probe across participants	There is a functional relationship between the VRA sequence and students' learning of different mathematical skills (i.e. place value, one-digit addition with regrouping, subtraction with regrouping, and one-digit multiplication) for both students. However, every student faced

25

		views of the strategy.					difficulty in maintenance and generalization in at least one skill. Adam and Zain responded positively to the VRA sequence. Adam stated that he did not like the abstract stage of all skills, while Zain liked the abstract VRA phase the most and the virtual the least.
4	Saunders et al . (2018)	Determining the effectiveness of using video prompting and exemplars to present real-life math problems on generalizing problem solving skills (number of steps taken correctly in analyzing tasks) for students with intellectual disabilities as well as using finger counting to solve problem; determining the participants' and teacher's perceptions of the effectiveness of solving math problems through video prompting and exemplars.	video prompting with systematic prompting and error correction procedures finger counting	Solving problems (addition, subtraction)	Three students with moderate intellectual disability, two males and one female, aged 12-13. Intermediate stage	Multi-probe across participants	There is a functional relationship between video prompting with systematic prompting, error-correction procedures, and finger counting. All participants pointed out that using video problems was fun. They liked solving math problems on computers. They learned to solve more math problems independently. The teachers also indicated that of this strategy is cost- and time-effective.
5	Orihuela et al . (2019)	determining the effectiveness of constant time delay educational package with multiple exemplars of the following shapes: (octagon, pentagon, hexagon, oval, square, triangle); determining the scope of acquisition of targeted shapes by students with moderate intellectual disabilities, and their ability to recognize new exemplars, and students' ability to acquire other targeted shape	instructional package consisting of a constant time delay procedure with multiple exemplars	Determine the target shapes (octagon, pentagon, hexagon, oval, square, triangle), and recognition of the names and spelling of shapes, and number of sides and angles)	Five students with moderate intellectual disability, four males and one female, aged 9-12 years; primary level	Multi-probe across participants	The instructional package (constant time delay and multiple shape exemplars) was effective. It enabled students to acquire knowledge of targeted shapes, and identify realistic exemplars of those shapes. All students demonstrated acquisition of more non-targeted information and were able to name shapes, spell their names, and identify the number of sides, and angles of shapes). Findings also showed that the procedure led to

		information (names, spelling, and number of sides, and angles).					generalizations on new exemplars.
6	Chapman et al. (2019)	Determine the effectiveness of presenting a problem though realistic functional description in writing as a visual aid; SLP, incorporating concrete methods to each functional problem, to solve algebraic problems; number of independent responses to task analysis by high school students with moderate intellectual disabilities; and determining students' ability to generalize skills of solving linear algebraic problems when performing functional tasks in a school environment	The problem in a realistic functional description and writing it as a visual aid, SLP, feedback, error correction and using concrete methods in each functional problem	Solve simple algebraic equations	Three male students with moderate intellectual disabilities, aged 14-15 years. High school	Multi-probe across participants	There is a functional relationship between the intervention package and solving algebraic equations. Incorporating a functional description and actual materials to an academic assignment helped participants generalize the skill to functional tasks in actual settings.
7	Root et & Browder (2019)	Determine the effectiveness of MSBI Teaching in solving algebraic problems “number of steps performed correctly”; determine the effect of modified schema-based instruction on the number of problems solved by students; determine the ability of students with intellectual disabilities to generalize problem-solving skills while gradually withdrawing visual support; identify the effect of continuous time delay on the definition of mathematical vocabulary by students with	modified schema-based instruction (SBI)، constant time delay	ability to solve algebra problems.	Three students with moderate intellectual disabilities, aged 13-14 years. Intermediate stage	Multi-probe across participants	There is a functional relationship between modified schema-based instruction and solving verbal math problems, as well as between continuous time delay and acquisition of math vocabulary, for independent correct definitions of mathematical words when symbols are given. Participants were able to correctly solve word problems and had some success in generalizing problem solving when visual support was withdrawn

		intellectual disabilities					
8	Jimenez & Saunders (2019)	determine the effect of simultaneous prompting on students' rapid visual recognition of quantities, on the student's speed in answering addition problems	simultaneous prompting	Rapid visual recognition of quantities, enhance the speed of solving two-digit addition problems	Three students, two males and one female with moderate intellectual disabilities, aged 8-12. Primary stage	Multi-probe across participants	There is a functional relationship between simultaneous prompting and rapid visual recognition of numbers and counting. The three students acquired quick visual recognition of quantities, and spent less time in in solving addition problems. Based on the SE teacher, the intervention was beneficial.
9	Book & Long (2020)	Determining the effectiveness of schematic diagram and SLP in solving problems on calculating price through a discount or voucher; identifying students' independence in using schematic diagrams to solve problems, and the extent of generalizing solution without using the schematic diagram; to identify students' perceptions of using schematic diagrams to solve problems.	a schematic diagram in conjunction with SLP	Functional mathematical skill (knowing the price of the commodity after discount)	Three students, two males with mild intellectual disabilities, and a 14-year-old female with autism High school	Multi-probe across participants	There is a functional relationship between the use of the schematic diagram and SLP and the accuracy of solving cost-finding problems after discount. Students, in general, were able to acquire and maintain problem-solving skills, but not all three were able to generalize solutions to problems without using the diagram. Two of the three students stated that they wanted to use the diagram to solve discount problems.

6.Determining Quality of Included Studies

The quality indicators provided in Horner et al. (2005) are used to assess the quality of studies in terms of description of study participants, dependent variables, independent variables, baseline, experimental control/internal validity, external validity, and social validity.

Through tracking quality indicators in the studies included in the current review, it was found that most of the reviewed studies adhered to quality indicators. Some studies failed to adhere to indicators. In relation to experimental control in (Saunders et al., 2018), the school year ended before the last participant was able to complete all three phases of intervention, which may threaten internal honesty. This is due to lack of controlling the time threat, as the study lasted for four months of the baseline, and schools were closed at that time.

As for Orihuela et al. (2019), the dependent variables were not described in a procedural and precise manner, and findings were not presented adequately. It is not stated whether findings are presented using visual analysis or otherwise. The functional relationship was not clarified, and no trend was indicated. Besides, findings varied in each stage. No comparison was made between stages in terms of direct immediate change, or analysis of variance, or the proportion of non-overlapping data. Similarly, in Champan et al. (2019) it is indicated whether findings are presented using visual analysis or otherwise. Although there is clarification of the level, trend, and variance of results in each stage, no comparison was made between the stages in terms of direct or relative instantaneous change, analysis of variance, or the proportion of non-overlapping data. There was also no gender diversity among participants as all participants in the study were male.

7.Findings and Discussion

Nine studies on strategies of teaching mathematics to students with intellectual disabilities were examined. The studies were published in nine different journals; namely, Journal of Behavioral Education; Remedial and Special Education; International Electronic Journal of Elementary Education; The Journal of Special Education; Research and Practice for Persons with Severe Disabilities; Exceptionality; Research in Developmental Disabilities; Education and Training in Autism and Developmental Disabilities; Focus on Autism and Other Developmental Disabilities. All studies were applied in the United States, except for one study that was applied in Turkey (Karabuluta & Özmen, 2018).

According to the time constraints of the current review, papers published in 2018-2021 were studied. However, research activity on this topic was concentrated between 2018 and 2019, with an average of four studies per year (Bouck et al., 2018; Karabulut & Özmen, 2018; Browder et al., 2018; Saunders et al., 2018; Orihuela et al., 2019; Jimenez & Saunders, 2019; Champan et al., 2019; Root & Browser, 2019). In 2020, only one study by Bouck and Long (2020) met the current review criteria. No study published in the current year, 2021, has yet been found. This may be due to the fact that this review is conducted at the beginning of the calendar year. It may also be due to the transition to distance education via the Internet and educational communication platforms.

Participants

The number of participants with intellectual disabilities in all nine studies covered by this systematic review was 31, of whom 19 were males, and 12 were females. Most of the studies (66%) dealt with both males and females (Karabulut & Özmen, 2018; Browder et al., 2018; Saunders et al., 2018; Orihuela et al., 2019; Jimenez & Saunders, 2019; Bouck & Long, 2020). Two studies (22%) were restricted to males (Champan et al., 2019; Bouck et al., 2018), and one study (11%) was restricted to females (Root & Browder, 2019). This shows that research focuses more on males than on females. This may be due to the gender differences in the prevalence of intellectual disability. Vashist et al., (2013) showed that the prevalence of intellectual disability is higher in males (87.4%) compared to females (21.6%). A recent systematic review on the incidence and prevalence of intellectual disability, indicates that prevalence of intellectual disability is higher among males than among females (McKenzie et al., 2016).

Ages of participants ranged between 8 and 15 years, distributed in three educational stages (primary, intermediate, and secondary). Two studies (22%) dealt with primary school participants (Orihuela et al., 2019); Jimenez & Saunders, 2019), and three studies (33%) on the intermediate school participants (Karabulut & Özmen, 2018); Root & Browder, 2018), while. Three studies (33%) also focused on secondary school participants (Bouck et al., 2018; Champan et al., 2019; Bouck & Long, 2020), while one study (11%) combined the primary and intermediate levels (Browder et al., 2018). The studies are almost equally distributed among the study stages.

The degree of disability of the participants varied between mild and moderate, but most studies dealt with participants with moderate intellectual disability. Figure (2) shows the percentage of distribution of studies according to the degree of intellectual disability. Six studies (66%) dealt with participants with moderate intellectual disability (Saunders et al., 2018; Browder et al., 2018; Orihuela et al., 2019; Jimenez & Saunders, 2019; Root & Browser, 2019; Champan et al., 2019). The remaining three studies (33%) dealt with participants with mild intellectual disability (Bouck et al., 2018; Karabulut & Özmen, 2018; Bouck & Long, 2020). Therefore, research focused on mild and moderate intellectual disability, while there were no participants with severe or acute intellectual disability. This may be due to the exclusion of children with severe to acute intellectual disability from education on the grounds that their disability renders them unable to learn (McKenzie et al., 2017).

Context

Most studies (89%) were conducted in public schools that provide classes for learners with intellectual disabilities (LID). Only one study (11%); namely, (Root et al., 2018) applied intervention in a LID private school. This explains the shift of policies internationally towards inclusive education for all students. Only 5% of countries have policies that provide for education in separate settings (UNESCO, 2018).

Research Design

All studies used multi-probe across participants (100%), which may be due to the suitability of this design to academic or functional math skills which are flexible and unlikely to change in the absence of an intervention using a multiple-screening design (Gast et al., 2018).

Strategies used in teaching mathematics to students with intellectual disabilities

Studies varied in terms of the strategies between the application of an educational package or using a single procedure for teaching mathematical skills. Most studies (67%) used an educational package such as prompting, video prompting, SLP, error correction, feedback, and finger-counting (Saunders et al., 2018); as well as chart-based instruction, graphic organizers, task analysis and self-monitoring, auto-learning, explicit instruction and error correction, feedback, metacognition, and thinking aloud (Browder et al., 2018). Another educational package consisted of constant time delay with three target shape exemplars (Orihuela et al., 2019). Besides, Chapman et al. (2019)applied a package consisting of adding a realistic functional description to algebraic problem, providing the problem in written form as a visual aid, SLP with feedback, error correction, and providing concrete materials for each problem. The use of schema-based teaching in addition to the continuous time delay was applied by Root & Browder (2019). Finally, Bouck & Long (2020) applied the schematic diagram plus SLP. On the other hand, the other three studies (33%) applied one teaching strategy: the virtual-representative-abstract (VRA) sequence (Bouk et al., 2018), the Understand and Solve! Strategy (Karabulut & Özmen, 2018), and simultaneous prompting (Jimenez & Saunders, 2019). Figure (3) shows the percentage of educational packages and single teaching strategies in the current review. The use of educational package by most studies may be due to the fact that the application of many recommended evidence-based practices is not isolated from the application of other practices (Richards-Tutor et al., 2016).

A review of the strategies employed by included studies reveals that some dealt with the same strategies. Three studies (33%) dealt with the use of SLP (Bouck & Long, 2020; Orihuela et al., 2019; Saunders et al., 2018). Three other studies (33%) dealt with the use of other curriculum instructions such as feedback and error correction (Browder et al., 2018; Saunders et al., 2018; Chapman et al., 2019), while the last three studies dealt with schema-based instruction (Root & Browder, 2019; Bouck & Long, 2020; Browder et al., 2018). Thus, SLP along with feedback and error correction, as well as schema-based teaching, is the most widely used strategy in teaching mathematical skills for students with intellectual disabilities. This finding is in agreement with that of Park et al. (2020), which concluded that prompting is the most widely used strategy in the teaching of people with intellectual disabilities.

Mathematical skills taught to students with intellectual disabilities

The mathematical skills targeted in this review are characterized by diversity in their scope and content. They included identifying geometric shapes, solving algebra problems, as well as subtraction and simple multiplication, addition with regrouping and subtraction with regrouping, knowledge of place value, identifying the different types of problems, realizing the price of a commodity after discount, quick visual recognition of quantities, and faster problem solving. Most studies (78%) dealt with academic math skill except for two studies (22%) that targeted functional math skill (Chapman et al., 2019; Bouck & Long, 2020). This finding confirms the findings of Chapman et al. (2019) that most studies tend to focus on the content of mathematics academically without including functional elements of that content, so that it is linked to the real experiences of people with intellectual disabilities.

Two studies (22%) dealt with the skill of solving algebra problems (Root & Browder, 2019; Chapman et al., 2019). Three studies (33%) also dealt with addition and subtraction skills (Saunders et al., 2018; Browder et al., 2018; Bouk et al., 2018), while one study (11%) included addition with regrouping and subtraction with regrouping. One-digit grouping and multiplication and recognition of the place value of numbers (Bouck et al., 2018), while the remaining three studies (33%) dealt with different skills. Orihuela et al. (2019) covered identifying geometric shapes, learning their names and spelling, and learning the number of their angles and sides. Bouck and Long (2020) targeted determining cost after discount. Finally, Jimenez and Saunders (2019) focused on rapid visual recognition of quantities, and determining the effect of rapid visual recognition on the speed and rate of student response to addition problems.

Accordingly, the most targeted skill is addition, followed by subtraction, and solving algebra problems. The least targeted are multiplication, recognition of geometric shapes, cost after discount, rapid recognition of numbers and speed of solving. This finding is in agreement with a previous systematic review (Bowman et al., 2019), which found that (75%) of the studies in their systematic review targeted skills related to numerals and operations, including doing arithmetic problems, counting items, identifying numbers, multiplication facts, one-digit verbal problems, and addition with regrouping, while 38% of studies targeted skills related to algebra.

Effectiveness of strategies used in acquiring math skills for students with intellectual disabilities

All studies proved the effectiveness of teaching strategies in imparting mathematical skills to students with intellectual disabilities at the intervention stage. Karabulut and Özmen (2018) found that the understand and solve strategy was effective in solving single-digit addition and subtraction problems. Browder et al. (2018) also stated that multiple intervention that includes modified schema-based instruction, task analysis, graphic organizers, self-monitoring, concrete methods of solving verbal problems, and problem-type identification is effective. Bouck et al. (2018) also confirmed the effectiveness of the VRA sequence strategy in learning place value skills, one-digit addition with regrouping, subtraction with regrouping, and one-digit multiplication. Saunder at al. (2018) referred to the effectiveness of video prompting along with SLP, and error-correction procedures in solving problems by finger counting. Orihuela et al. (2019) underscored the effectiveness of the constant time delay and multiple-shape exemplars educational package in acquiring knowledge of targeted geometries, in addition to learning how to identify target shapes through realistic exemplars. All students acquired additional non-target information (names of shapes, their spelling, and number of sides and angles).

Root and Browder (2019) demonstrated the effectiveness of modified schema-based instruction in solving verbal problems, in addition to the effectiveness of the continuous time delay and the acquisition of mathematical vocabulary “defining mathematical terms when given the symbol”. Jimenez and Saunders (2019) found the simultaneous prompting in acquiring the skill of rapid visual recognition of quantities effective, and noted that students spent less solving addition problems. In the same vein, Chapman et al. (2019) proved the effectiveness of the intervention package of presenting the problem through a realistic functional description, presenting the problem in writing, SLP, feedback, error correction, and adding concrete methods to each functional problem in solving algebraic equations. Bouck and Long (2020) also indicated the effectiveness of using the systematic diagram and SLP in the accuracy of solving cost-finding problems after discount.

In spite of the effectiveness of all teaching strategies in acquiring mathematical skills at the intervention stage, there is discrepancy in the level of effectiveness between the maintenance and generalization stages. Most studies (89%) reported that all participants were able to maintain skills at the maintenance stage. However, in one study (11%) all participants encountered difficulties during the maintenance phase (Boucl et al., 2018). Regarding the generalization of skills, there was variation among studies. Three studies (33%) reported a full generalization of skills (Karabulut & Özmen, 2018; Browder et al., 2018; Champan et al., 2019), while two studies (22%) reported achieving partial generalization (Orihuela et al., 2019); Root & Browder, 2019). Moreover, two studies (22%) reported a lack of skill generalization after the intervention was withdrawn (Bouck & Long, 2020; Bouck et al., 2018). The remaining two studies (22%) did not definitively report generalization in study procedures (Saunders et al., 2018; Jimenez & Saunders, 2019) as the school year ended before performing the generalization.

8. Conclusion

Using special teaching strategies in imparting mathematical skills to students with intellectual disabilities is urgently needed (Agodini et al., 2010). Studies point to expanding the scope of mathematical content for people with intellectual disabilities, rather than focusing on numbers and operations (Bowman et al., 2019). However, studies still focus on academic content, and few of them are keen to include a functional realistic component in teaching academic content (Chapman et al., 2019). Studies also point to the lack of consensus on the criteria for conducting the maintenance stage with regard to its duration and number of sessions. Studies tend to use educational packages that incorporate more than one strategy or educational material (Park et al., 2020).

Findings of the current review demonstrate that most of the studies used educational packages, while three studies used single strategies. Therefore, researchers should pay more attention to intervention packages and exploring questions such as: what teaching methods or materials shall be used in the instruction packages? What packages are effective for different mathematical skills? Are there differences between single strategies and instruction packages in teaching mathematical skills to people with disabilities? In addition, future reviews shall also focus on differences among students with intellectual disabilities, such as the participants' learning features, and how difference might affect instruction strategies and targeted mathematical skills.

Findings of the current study also indicate that there is a disparity in maintenance and generalization among students after withdrawing the interventions. Therefore, the current review suggests conducting longitudinal studies to assess the effects of future interventions on maintaining and generalizing skills. Given that most of the studies in the current review apply interventions at school, we recommend applying interventions outside the school setting to enhance generalization by people with intellectual disabilities. As findings of this study focus on arithmetic skills such as addition, subtraction, and multiplication, this review suggests additional research on interventions in teaching more advanced mathematical skills, such as fractions, and data analysis for students with intellectual disabilities. Since the studies covered by this review focus on academic mathematics, the current review recommends that teachers should integrate objectives of academic and functional mathematics when teaching mathematical concepts to enable students with intellectual disabilities to acquire the functional mathematical skills that they desperately need in their daily lives. Moreover, the Ministry of Education needs to develop a curriculum that may enhance the exposure of students with intellectual disabilities to real life situations.

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