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Early Number Development in Children with Special Needs: Correspondence, Classification, Comparison and Seriation

Abstract

Early number skills/concepts mean the skills and concepts that must be gained before number acquisition. We can get those prerequisite skills from the theory of Piaget's Cognitive Development; correspondence, classification, comparison and seriation. These skills, which are essential for all children, take a much larger place in the lives of children with special needs who have difficulty in understanding abstract concepts. The aim of this review study is to give information on the concepts of correspondence, classification, comparison, and seriation studied before the acquisition of the number concept and investigate the research on the concepts and skills before number acquisition in children with special needs. This review study was conducted with 22 studies, which met the inclusive criteria. The studies were examined in terms of skills, design, and interventions. Results showed that classification and seriation were the most studied skills in the studies and effective practices were used in teaching early number skills or concepts. These effective practices were explained and implications for future research were discussed.

Keywords: kindergarten, early number development, early numeracy, piagetian operations

Introduction

The foundation of mathematical concepts is laid during the preschool period. During this period, the way children think and perceive the environment differs considerably from that of adults (Reys, Lindquist, Lambdin, & Smith et al., 2009). Children's desire to explore pushes them to investigate their world. They begin to perceive the world and learn with all their sensory organs. Therefore, many cognitive processes, such as mathematical thinking, organization, and establishing associations, begin to develop at a very early age (Wright, Martland, & Stafford, 2006). During the early childhood ages, mathematic teaching is a priority to make a base for further learnings in the development of numerical learnings.

The development of the number concept, which forms the basis of mathematics, and counting skills also coincides with the early childhood period (0-6 years) (Baroody, Lai, & Mix, 2005; Saxe et al., 1987). The number concept is a concept which children may encounter everywhere, starting from their perception of the environment, which they use in many routines such as shopping, eating, reading books, doing sports, either consciously or unconsciously. We must have certain prerequisite skills in order to be able to learn all the skills (recognizing numbers, counting by heart, meaningful counting, etc.) related to the number concept, which is so much intertwined with life

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(Miller, Stringfellow, Kaffar, Ferreira, D. & Mancl, 2011; Reys et al., 2009; Smith, 2006). Early number skills/concepts mean the skills and concepts that must be gained before number acquisition (Saxe et al., 1987; Van de Rijt and Van Luit, 1998; Van Luit and Schopman, 2000). One of the important parts in mathematic teaching is about being aware of early numeracy for young infants (Mononen, Aunio, Koponen, & Aro, 2014). Research findings showed that the relationship between early number concepts and mathematics achievement was strong and early number concepts were very important in elementary school mathematics (Jordan, Glutting, Dyson, Hassinger-Das, & Irwin, 2009; Omotoso and Shapiro, 1976; Perry Pasnak, & Holt, 1992).

These skills, which are essential for all children, take a much larger place in the lives of children with special needs who have difficulty in understanding abstract concepts. Piaget's Theory assumes an invariant sequence of intellectual stages of development, rather than age-related maturation (Campbell, McCutcheon, Perry, & Pasnak, 1988). The literature indicates that the cognitive development of children with intellectual disability, learning disability, autism or children at risk can be supported through instruction on early concrete operational constructs and early number concepts (Pasnak, Campbell, Perry, & McCormick, 1989; Pasnak, Hansbarger, Dodson, Hart, & Blaha,1996; Pasnak, Maccubbin, Campbell, & Gadzichowski, 2004).

In the literature, two terms, early number development and early numeracy concepts/skills are used. Often used interchangeably, these terms may vary in content (Wright et al., 2006).

Early Number Development and Early Numeracy

One-to-one correspondence, number sense, order, cardinal principle, ordinal principle, basic arithmetic, number orientation, count, identifying numbers, shape recognition, patterning, problem-solving, comparing properties were discussed within early numeracy competencies (Baroody et al., 2005; Notari-Syverson and Sadler, 2008; Raghubar and Barnes, 2017; Van Rooijen, Verhoeven, & Steenbergen, 2010; VanderHeyden et al., 2011; Wright et al., 2006). Furthermore, four prerequisite skills of the number concept (Van Luit and Schopman, 2000) were added to these early numeracy skills (Van de Rijt and Van Luit, 1998): (a) correspondence, (b) classification, (c) comparison, and (d) seriation. We can get those prerequisite skills from the theory of Piaget's Cognitive Development (Kroesbergen, Van Luit, Van Lieshout, Van Loosbroek, & Van de Rijt, 2009; Lemoyne and Favreau, 1981; Malabonga, Pasnak, Hendricks, & Southard, 1995; Van de Rijt and Van Luit, 1998; Van Luit and Schopman, 2000). These skills are involved in early number development and related to counting skills (Saxe et al., 1987). Early numeracy includes basic arithmetic, operations, problem-solving, identifying numbers, etc., in addition to the number concept. It can be said that the early numeracy term is more inclusive than the early number term. The correspondence, classification, comparison, and seriation constituting early number concepts form part of the early numeracy (Saxe et al., 1987; Van Luit and Schopman, 2000). In this study, the term "early number concepts or skills," which includes pre-number concepts and relates to number and counting (correspondence, classification, comparison, and seriation), was used.

Key competencies for preschool are number sense, one-to-one correspondence, classification, comparison, seriation (ordering), equality, increase, decrease, etc. before learning to count (Notari-Syverson and Sadler, 2008; Wright et al., 2006). In this study, correspondence, classification, comparison, and seriation (ordering), which are prerequisite skills of the number concept and known as Piagetian operations, were discussed.

All these concepts form the basis of mathematics and are studied frequently in the early childhood. In the literature, certain review studies were also carried out on teaching early numeracy concepts to preschool or early childhood children with special needs. In the meta-analysis study they published, Kroesbergen and Van Luit (2003) investigated mathematical interventions in the fields of preparatory mathematics, basic skills, and problem-solving strategies aimed at primary school students who had difficulty in mathematics

and were diagnosed with learning difficulty and intellectual disability (the mean age of 8.6). The majority of the included studies explained interventions in the domain of basic skills. Although the overall interventions were found to be effective, direct instruction and self-instruction were found to be more effective than mediated instruction. Furthermore, interventions that included the use of computer-assisted instruction and peer tutoring showed a smaller effect than others.

In the review study examining eight studies in which the early number skills of children with cerebral palsy (CP) (the age range of 6-9) were investigated, it was concluded that children with cerebral palsy were behind their peers in performing simple arithmetic operations. The available studies in the review do not provide enough information about the content of interventions for children with CP (Van Rooijen et al., 2010). Another study reviewed early numeracy interventions for 4-7-year-old children at risk for mathematics difficulties. The study analyzed the effectiveness and component of interventions: duration, setting, numeracy content, and measurement. The results indicated that interventions had various effects, explicit instruction, game playing, computer-assisted instruction, concrete-representational-abstract strategy were found to be effective in improving mathematics performance (Mononen et al., 2014).

Raghubar and Barnes's (2017) study provided a review of the development of early numeracy in children with mathematical learning disabilities and spina bifida aged 4-6 years and examined interventions. The results indicated that learning to count, identify numbers, and compare properties are key early numeracy skills. For learning these skills, math-specific interventions are the most effective for children at risk or with mathematical learning disabilities.

In the aforementioned reviews published on the topic of early numeracy, preparatory mathematics skills, basic skills, basic arithmetic, problem-solving strategies, numeracy concept, measurement, counting, identifying numbers, and comparing properties were examined. These skills are related to numeracy, pre-number concept, and also the number concept. Therefore, mathematical skills after number concept acquisition were also involved in these reviews.

The differences of this study from other review studies can be listed as follows: (a) Unlike other review studies, it investigated the research on correspondence, classification, comparison, and seriation which are prerequisite skills of the number concept from the theory of Piaget's Cognitive Development skills (early number development) before the development of the number concept rather than the skills after the acquisition of the number concept. (b) Since the development of the number concept corresponds to the age interval between 5 and 7 years, it investigated the research with participants in the early childhood period (0-6) who had not acquired the number concept. (c) It investigated the studies of which participants included children with special needs. It is thought that the study will contribute to the literature because it addresses the listed differences.

In addition to contributing to the literature, this study is also important in terms of examining the concepts that form the basic of mathematics. While these concepts form the basis of mathematics for all children, they are of vital importance for children with special needs who fall behind their peers in terms of their cognitive characteristics, have difficulty understanding abstract concepts, and who have learning disabilities, autism or intellectual disabilities. If early number concepts do not occur at an early age, children with special needs may have difficulty in acquiring advanced mathematical concepts (Van Luit and Schopman 2000). The results of a study state that early number skills/concepts could be strong early screeners in the detection of mathematical disabilities, and classification, comparison, seriation, conversation, and counting knowledge have an important role in the development of number and numerical arithmetic (Stock, Desoete, & Roeyers, 2009). Therefore, examining what these concepts are, how they are used and how they are taught will shed light on teachers and families in working children with special needs. In addition, the teaching of early number concepts will play a major role in preventing mathematics difficulties in the coming years.

Aims of the Present Review

The aim of this review study is to give information on the concepts of correspondence, classification, comparison, and seriation studied before the acquisition of the number concept and investigate the research on the concepts and skills before number acquisition in children with special needs. Accordingly, this review study (a) explained correspondence, classification, comparison, and seriation, which are prerequisite skills for the number concept, (b) examined the studies on early number in children with special needs. To realize these aims, the following research questions were addressed:

1. What are the early number concepts (correspondence, classification, comparison, and seriation)?
2. Is there a trend in the outcomes of study properties (year of publication, design, participants, intervention)?
3. What are the special needs (developmental disability, dilfficulty, diversity) of the participants?
4. What are the early number skills/concepts studied in the research? Which concept or skill was most investigated?
5. Which interventions (treatments) have been successful in the acquisition of early mathematics skills?

Method

Literature Search Process

The studies in the literature were searched using several educational databases in this review. These databases were Ebscohost, Jstor, Google Scholar, OECD iLibrary, Sage, Scopus, SpringerLink, Taylor & Francis, and Web of Science. When searching the studies various combinations of keywords; “early number,” “early numeracy,” “matching,” “correspondence,” “grouping,” “classification,” “comparison and seriation,” “early counting,” “early math in special education,” “early number in children with special needs,” “young children with mathematical difficulties,” “Piagetian,” “Piaget operations” were used. The literature review took place between 1975 and 2019. 50 studies were reached in the first search on the database with keywords, and 22 of them met the criteria. Therefore, 22 studies in Table 1 were included in the study. All search process was carried out by the author but an independent researcher participated in the relability process.

Inclusion Criteria

The criteria for the inclusion of studies were as follows:

1. The study should be a published article in a refereed journal.
2. Early number concepts consisting of skills before number acquisition should be studied in the study.
3. These skills or concepts studied should include at least one of the concepts of correspondence, classification, comparison, and seriation.
4. The study had to have an intervention that focused on early number concepts/skills.
5. The research should be carried out with children with special needs in the preschool period (0-8 age range).
6. The study should be applied research, so it should conduct with an experimental design, single subject design or case study.

Exclusion Criteria

The criteria for the exclusion of studies were as follows:

1. Thesis, books, book chapters, reports, news and unpublished articles were not included.
2. Studies with early numeracy skills after number acquisition such as number recognition, counting, basic addition with objects, but without correspondence, classification, comparison, and seriation were not included.
3. Even if the study includes one of the early number concepts (correspondence, classification, comparison, and seriation) was not included if it covered the process after number acquisition and the participants were over 8 years old and/or were not with special needs.
4. If the study did not involve an intervention, that is, the review or descriptive study, it was not included.
5. The study was not included if the participants were over 8 years old and/or without special needs.

6. The study was not included if it conducted with a descriptive study or a review.

Reliability

The independent researcher is PhD in special education and carries out studies in the early childhood. After completing the stage of determining the subject, forming the research questions, and searching, the studies were examined by the author in terms of five parameters consisting of participant, design, intervention, target skill and result, seen in Table 1. Ten studies randomly selected among 22 studies that met the criteria were examined according to five parameters by the independent researcher. Prior to this, the author provided the independent researcher with detailed information about study, both orally and in writing. The independent researcher examined 10 studies in terms of five parameters and coded them in 50 items. The evaluations of the two researchers were compared. In the first stage, in three studies, a different opinion was appeared for a total of five items (*intervention and *target skills) and reliability was calculated as 90%. A more detailed explanation about math interventions and early number concepts was made by the author, and agreement was reached on these items, finally reliability was calculated as 100%.

Results

In this review, early number skills (correspondence, classification, comparison, and seriation) which are prerequisite skills of numeracy and counting known as Piaget's concept of number development were explained to answer the first research question. The study confirmed the value of the early number skills or concepts of children with special needs and highlighted the relationship of number development and correspondence, classification, comparison, and seriation skills in children with special needs.

This review also examined the studies on early number in children with special needs. Twenty-two studies which met the criteria were encountered. Table 1 presents an overview of the studies in this review.

Correspondence, Classification, Comparison and Seriation

The early number concepts were defined to answer *the first research question.* Correspondence, classification, comparison and seriation (order) are prerequisite skills of numeracy and counting known as Piaget's concept of number development (Lemoyne and Favreau, 1981; Malabonga et al., 1995; Reys et al., 2009; Van de Walle and Lovin, 2006). Piaget argued that the construction of a number concept depended on the development of correspondence, classification, seriation (order), and comparison skills (Baroody et al., 2005).

These concepts are acquired as correspondence, classification, comparison, and seriation, respectively, and they are hierarchical skills. In other words, it is not cognitively meaningful for a child, who does not have acquired the correspondence skill, to perform classification and a child, who does not have acquired the comparison skill, to perform seriation (Inhelder and Piaget, 2007; Lemoyne and Favreau, 1981; Platz, 2004; Reys et al., 2009). Considering the learning characteristics of children with special needs, it can be said that the correspondence, classification, comparison, and seriation skills make up the basic skills for the acquisition of abstract skills in mathematics.

Correspondence means exact compliance. This skill, which forms the basis of the number system, must be acquired at an early age. Children can perform correspondence after the development of the concept of "same" (Reys et al., 2009; Smith, 2006). The correspondence skill is the prerequisite skill for number conservation during the preoperational stage. The National Council of Teachers of Mathematics (NCTM, 2000) states that the exact correspondence skill is related to meaningful counting (Charlesworth, 2011). Correspondence is realized between objects, visuals, or symbolic expressions. Correspondence is made between objects and objects, objects and visuals, visuals and visuals, visuals and symbols (numbers) or objects and symbols (numbers), respectively, and lastly, between numbers and numbers. An appropriate example of this sequence is the correspondence between two erasers among erasers and pencils (object-object), the correspondence between the eraser and the visual of an

eraser among erasers and pencils (object-visual), the correspondence between two eraser visuals among the visuals of erasers and pencils (visual-visual), the correspondence between three erasers and the number 3 (object-number), the correspondence between the visual with three erasers on it and the number 3 (visual-number), and two papers with the number 3 on them (number-number).

Classification is the process of bringing together objects, visuals or symbols according to their features and dividing them into groups. Children learn to establish associations between similar objects through classification. The classification skill, which forms the basis of the number concept and operation, is also the prerequisite for comparison and counting skills (Platz, 2004; Smith, 2006). Children who learn classification see the "similarity or sameness" between entities. In the classification skill, first, objects and then visuals are classified, and it is tried to make classification according to one feature first and then multiple features in the coming years. For example, let us consider the "geometric shape" class; "triangles" is a classification as the subset of this class, and when we say "blue triangles," we make classification according to two features, both the number of sides and color. When working with children, posing the question "Classify the same fruits on the plate," forms the logic of the counting operation by having them answer the questions "how many" and "which."

Comparison is the process of determining whether two objects are the same or different according to a particular feature. It is necessary to have acquired the concept of "different" in order to be able to make a comparison (Smith, 2006). Therefore, a child is expected to distinguish the unrelated features of objects in order to be able to compare two objects (Platz, 2004; Reys et al., 2009). Comparison is a prerequisite for the seriation skill, which involves comparing multiple objects. In the comparison process, it is observed that the concepts of location, quantity, size, distance, and time are usually compared (Reys et al., 2009; Smith, 2006). Examples such as on-under, right-left, big-small, thick-thin, tall-short, near-far, little-much, heavy-light, inside-outside can be given. It is possible to compare objects according to one feature (comparing hazelnuts in different quantities on two different plates as little-much) or multiple features (making a comparison of which one is more and lighter when there are 10 hazelnuts on a plate and 15 small pieces of cotton on the other plate).

Seriation is the process of ordering two or more than two objects according to particular features. The seriation skill is the most complex skill among early number skills, which is also learned the last because it requires making multiple decisions simultaneously (Platz, 2004; Reys et al., 2009; Smith, 2006). In order to perform seriation, it is necessary to have acquired the classification and comparison skills first. Children make a comparison by determining the common features of objects (classification) when performing seriation (Van de Walle and Lovin, 2006). In seriation, a logical ordering is made based on the gradual change of a series of objects according to a single feature (the ordering of sticks from long to short) or the repetition of certain features in consecutive order (Malabogna et al., 1995).

Year of Publication, Design, Participants, and Interventions

When we address *the second research question*, it can be said that teaching early number skills to children with special needs began to be studied in the near past since the studies met the criteria were carried out between 1988 and 2013, and it is not an intensively studied area nowadays. A vast majority of the research models consisted of experimental research designs since one of the selection criteria of studies is that "the research should include interventions." Accordingly, two of the studies were designed with the single-subject design (Hitchcock and Noonan, 2000; Pasnak et al., 2004), one was designed as the case study (Goodman et al., 2011), and the remaining 19 studies were designed with the experimental design. Which design of the experimental design method is used is expressed in only five of these 19 studies, and two of them are the pre-test post-test control group design (Bryant et al., 2011; Tatar and Sharifi, 2011), two are the pre-test, post-test and delayed post-test (Dyson et al., 2013; Jordan et al., 2012), and one is an advanced design (Kidd et al., 2008). A social validity study could not be carried out in any of the studies.

Table 1.
Overview of the Studies Included in the Review

Reference	Participants			Design	Intervention	Target Skills	Result
	N	Age	Special Needs				
1) 1988, Campbell, McCutchheon, Perry & Pasnak	10 exp. 10 con. 20 total	6-8	Intellectual disability	Unstated (Quasi experimental design)	Piacceleration instruction	Classification, seriation	Piacceleration instruction was effective on teaching classification and seriation also Piagetian principles can be taught to children wtih intellectual disabilities.
2) 1989, Pasnak, Campbell, Perry, & McCormick	6 total	6-8	Intellectual disability	Unstated (Quasi experimental design)	Piacceleration instruction	Undimensional classification and seriation	Pretest scores were better than posttest scores all children although with large individual differences remaining between children.
3) 1991, Pasnak, Holt, Campbell & McCutcheon	28 exp. 29 con. 57 total	5-6	Low ability Language difficulty Normal development	Unstated (Experimental design)	Piacceleration instruction	Unidimensional classification, seriation and number conservation	Experimental group performed differently than control group. Piacceleration was a useful instructional program for improving early math skills.
4) 1992, Perry, Pasnak, & Holt	12 exp. 12 con. 24 total	6-9	Intellectual disability	Unstated (Quasi experimental design)	Piacceleration instruction	Correspondence, comparison, classification, seriation, drawing numbers, coins	The results were positive for both children who followed IEP (control) and who had piacceleration inst. But the experiment group outscored the control group.
5) 1993, Waiss & Pasnak	12 exp. 12 con. 24 total	5-7	English as a second language and low ability	Unstated (Experimental design)	The Orientation Training Set, The Succesive Classification Set, The Conservation Training Set through coaching	Unidimensional classification, orientation, and number conservation	The significant difference in scores of experimental and control groups on the measure, not an instruction effect.
6) 1994, Malabogna, Pasnak, & Hendricks	8 exp. 7 con. 15 total	5-6	English as a second language and low ability	Unstated (Quasi Experimental design)	Exp: Piagetion operations learning set vs Con.: flashcard, bingo games	Generalization of classification and seriation, letter, number, counting	The differences between two groups were significant for classification but not for seriation. In seriation both of two groups' scores were good.
7) 1995, Pasnak, Perry, Whitten, Waiss, Madden, &Watson-White	22 exp. 22 con. 44 total	5-8	Intellectual disability	Unstated (Quasi Experimental design)	Piacceleration instruction	Unidimensional classification, seriation, and number conservation	The significant difference in scores of experimental and control groups on the all measures. Piacceleration was better than standart curriculum.
8) 1996, Pasnak, Hansbarger, Dodson, Hart, & Blaha	32 exp. 32 con. 64 total	5	Low ability Mathematical difficulties Normal development	Unstated (Experimental design)	Piacceleration instruction	Unidimensional classification, seriation, and number conservation	The experimental group mastered the classification, seriation, and conservation skills via piacceleration and scored better psychometric measures.

Note: exp.: experimental group con.:control group

Table 1.
(*continue*)

Reference	Participants			Design	Intervention	Target Skills	Result
	N	Age	Special Needs				
9) 1996, Pasnak, Madden, Malabogna, Holt & Martin	22 exp. 25 con. 47 total	6-7	Low ability Mathematical difficulties Normal development	Unstated (Experimental design)	Piacceleration instruction	Unidimensional classification, unidimensional seriation, and number conservation	Psychometric measures scores for both group were higher than a year before. The experimental group continued to outperform the control group.
10) 1997, Rhodes, Whitten, & Copeland	28 exp. 28 con. 56 total	4-6	English as a second language and high risk	Unstated (Experimental design)	Piacceleration instruction	Classification, seriaton, number conservation, number recognition and counting	Experimental group significantly better than control group on measures of general classification and seriation.
11) 1998, Van de Rijt & Van Luit	53 exp. 53 con. 106 total	4-7	Low ability Mathematical difficulties	Unstated (Experimental design)	The Additional Early Mathematics (AEM) Program	Comparison, classification, correspondence, seriation, counting, knowledge of numbers	The mean early mathematical competence scores of experimental groups differs significantly of the mean early mathematical competence score of control groups. The program is effective on early math competence.
12) 2000, Hitchcock & Noonan	3 boy 2 girl 5 total	3-5	Intellectual disability	Single subject design (an adapted alternating treatmens)	Constant time delay under two conditions: Computer Asisted Instruction and Teacher-Assisted Instruction	Matching shapes, colors and numbers (correspondence)	All participants in this study significantly improved their mathcing skills. Computer-assisted instruction was the most effective method for all participants on all skills.
13) 2000, Van Luit & Schopman	62 exp. 62 con. 124 total	5-7	Mild intellectual disability	Unstated (Experimental design)	Early Numeracy Program	Correspondence, comparison, classification, seriation, counting, numbers, generalization	Experimental group made better progress with regard to early numeracy than the comparison group.
14) 2004, Pasnak, Maccubbin, Campbell, & Gadzichowski	1 boy	14 (4*)	Severe intellectual disability	Single subject design (a multiple baseline design)	The Learning Set Approach	Classification (oddity) and seriation	There was significant gain in seriation when seriation was taught, in oddity when oddity was taught.
15) 2007, Kroesbergen, Van de Rijt, & Van Luit	15 low 111 total	5-6	Mathematics learning disabilities	Experimental design	Seriation training with feedbacks	Comparison, seriation, using counting words, structured counting, resultative counting, numbers	Children performing low at preparatory math skills received training and children's planning scores increased more than IQ scores. Training was effective on early mathematics skills.
16) 2008, Kidd, Pasnak, Gadzichowski, Ferral-Like, & Gallington	26 exp. 26 con. 52 total	4-5	English as a second language and high risk Normal development	Experimental design (an advanced design)	The Learning Set Approach	Classification (oddity), orientation, seriation, and number conservation	The instruction via The Learning Set Approach was effective method on early number skills.

Note: exp.: experimental group con.:control group

Table 1.
(*continue*)

Reference	Participants			Design	Intervention	Target Skills	Result
	N	Age	Special Needs				
17) 2009, Räsänen, Salminen, Wilson, Aunio, & Dehaene	15 A 15 B 29 con. 59 total	6	Low ability Mathematical difficulties	Unstated (Experimental design)	Computer-Asisted Interventions: The Number Race (A) vs Graphogame-Math (B)	Number comparison, correspondence labels and number symbols, number sense	Both interventions improved children's comparison skills, compare to control group, but experimental groups did not differ from control group in other numerical skills.
18) 2011, Bryant, Bryant, Roberts, Vaughn, Pfannenstiel, Porterfield, & Gersten	139 exp. 65 con. 204 total	6-7	Low ability Mathematical difficulties	Experimental design (pre test post test control group design)	Early Mathematics Tier 2 Intervention	Conceptual and procedural knowledge, counting, comparison, seriation (ordering), classification, compose, decompose, part-whole	Experimental groups statistically significant higher scores than control groups in early math skills.
19) 2011, Goodman, Bains, & Moussalli	2 girl 4 boy 6 total	4-6	Autism, Intellectual disability, Learning disability	Unstated (Case studies)	IEP Workboxes	Concept development, sound out letters, one to one correspondence of numbers, matching sound and number/letter	Childrens received instruction based on their IEP workboxes for 8 months. At the end of the year, IEP objectives had been mastered by each of six children.
20) 2011, Tajar & Sharifi	30 exp.(LD) 30 con.(LD) 15 exp.(N) 15 con.(N) 90 total	6	Learning disability (LD) Normal development (N)	Experimental design (pre test post test control group design)	Reparative education method	Open-closed, up-down, inside-outside, classification, correspondence, smaller-bigger, adaptation number with object or Picture, before-after, one-decimal, light-heavy	There is a significant difference between average of groups. Reparative education effected on improving mathematics in children with LD. But the performance of normal group is better than LD group.
21) 2012, Jordan, Glutting, Dyson, Hassinger-Das, & Irwin	44 exp.1 44 exp.2 44 con. 132 total	5-6	Low ability, Mathematics difficulties	Experimental design (pretest, posttest and delayed posttest)	Number sense intervention and language intervention	Counting, number recognition, number comparison, nonverbal calculation, story problem, number combination, verbal subiziting, finger use, part-whole, write number	The number sense group (1) outperformed the control in most areas. There were no differences the language (2) and control groups on any early math skills.
22) 2013, Dyson, Jordan, & Glutting	56 exp. 65 con. 121 total	5-6	High risk, Mathematics difficulties	Experimental design (a pretest, posttest and delayed posttest)	Regular kindergarten math program: Math Trailblazers (with using scripts, pointing gestures, materials)	Number recognition, finger use, correspondence, number comparison, number seriation, part-whole, counting, verbal subitizing	The experimental group made larger gains than the control group. Number sense intervention for kindergarteners is effective.

Note: exp.: experimental group con.:control group

The ages of the participants in the studies varied between 3-9, and the majority of them were preschool students. Only one study included a 14-year-old boy with severe intellectual disability, but his mental age was indicated as 4, and he received preschool education. When the ages of the participants in Table 1 are examined, it can be said that most of the studies aimed at teaching early number skills to children with special needs were carried out during the preschool period at 4 years of age and above, and studies for the early childhood period of 0-3 years were limited.

When the special needs of the participants were investigated in order to *answer the third research question*, it was observed that 12 studies used English as a second language and dealt with children with low cognitive ability and/or mathematical difficulties (Bryant et al., 2011; Dyson et al., 2013; Jordan et al., 2012; Kidd et al., 2008; Malabogna et al., 1994; Pasnak et al., 1991; Pasnak et al., 1996; Pasnak, 1996; Rasanen et al., 2009; Rhodes et al., 1997; Waiss and Pasnak, 1993; Van de Rijt and Van Luit, 1998), three studies dealt with children with learning disability (Goodman et al., 2011; Kroesbergen et al., 2007; Tatar and Sharifi, 2011), eight studies dealt with children with intellectual disability (Campbell et al., 1988; Goodman et al., 2011; Hitchcock and Noonan, 2000; Pasnak et al., 1989; Pasnak et al., 1995; Pasnak et al., 2004; Perry et al., 1992; Van Luit and Schopman, 2000), one study dealt with children with autism (Goodman et al., 2011), and one study dealt with children with language difficulties (Pasnak et al., 1991). Accordingly, in all of the relevant studies, the special needs of the participants are related to the difficulties in mental processes. Moreover, it can be said that the most common types of disability in the studies are related to individuals at risk of difficulty in studying English as a second language, low cognitive ability and/or mathematical difficulties, and learning disability.

As can be seen in Table 1, the interventions carried out in all studies were found to be effective in teaching early number skills/concepts. The interventions used in the studies are *Piacceleration Instruction, *The Training Sets of The Orientation, Classification, Conservation, *Piagetion operations learning set vs. flashcard, bingo games, *The Additional Early Mathematics (AEM) Program, *Constant Time Delay under two conditions: Computer Assisted Instruction and Teacher-Assisted Instruction, *Early Numeracy Program, *seriation training with feedbacks, *The Learning Set Approach, *Computer-assisted intervention: The Number Race and Graphogame-Math, *Early Mathematics Tier 2 Intervention, *regular kindergarten program, *IEP Workboxes, *reparative education method, *number sense intervention. Piacceleration instruction was used in eight of the studies (Campbell et al., 1998; Pasnak et al., 1989; Pasnak et al., 1991; Pasnak et al., 1995; Pasnak et al., 1996; Pasnak et al., 1996; Perry et al., 1992; Rhodes et al., 1997). Accordingly, in this review study, it can be stated that the Piacceleration instruction method is frequently used in teaching early number skills/concepts to children with special needs. The contents and common features of the interventions used in the studies were discussed in the fifth research question.

The Early Number Skills or Concepts in the Studies

When the skills or concepts in the studies are examined to answer *the fourth research question*, it is observed that the skills are correspondence, classification, comparison, seriation, number recognition, number conservation, counting, finger use, number sense, number combination, number generalization, nonverbal calculation, conceptual & procedural knowledge, part-whole, spatial relations, orientation, adaptation number with object, verbal subitizing, picture, letter, or sound. Among these skills, classification and seriation are the most widely studied skills, each oh them was studied in sixteen studies (Bryant et al., 2011; Campbell et al., 1998; Dyson et al., 2013; Kidd et al., 2008; Kroesbergen et al., 2007; Malabogna et al., 1994; Pasnak et al., 1989; Pasnak et al., 1991; Pasnak et al., 1995; Pasnak et al., 1996; Pasnak et al., 1996; Pasnak et al., 2004; Perry et al., 1992; Rhodes et al., 1997; Tatar and Sharifi, 2011; Waiss and Pasnak, 1993; Van de Rijt and Van Luit, 1998; Van Luit and Schopman, 2000),

In four studies, correspondence, classification, comparison, and seriation were studied with numbers (Bryant et al., 2011; Dyson et al., 2013; Goodman et al., 2011;

Jordan et al., 2012), in twelve studies, these skills were studied between objects and images (Campbell et al., 1988; Hitchcock and Noonan, 2000; Kidd et al., 2008; Pasnak et al., 1989; Pasnak et al., 1991; Pasnak et al., 1995; Pasnak et al., 1996; Pasnak et al., 1996; Pasnak et al., 2004; Perry et al., 1992; Rhodes et al., 1997; Waiss and Pasnak, 1993), and in other six studies, these skills were studied both with objects and numbers (Kroesbergen et al., 2007; Malabogna et al., 1994; Rasanen et al., 2009; Tatar and Sharifi, 2011; Van de Rijt and Van Luit, 1998; Van Luit and Schopman, 2000). It can be said that more than half of the studies examined early number skills with objects. The reason for this is that most studies used Piacceleration instruction, which is a learning set technique, and employed concrete objects.

Interventions Used in Teaching Early Number Skills or Concepts

In order to answer *the fifth research question,* the interventions which were found to be effective in teaching early number skills/concepts in the studies, their common features, and their impact on learning were discussed under this heading.

The Piacceleration Instruction: The Piacceleration (PXL) instruction program was developed by Carr, Pasnak, and Campbell in 1986. The PXL focuses on Piagetian constructs (Campbell et al., 1988) and also can be developed out of efforts to use learning sets to teach classification, orientation, seriation, and number conservation (Pasnak et al., 1991). The PXL uses common objects and learning sets to teach Piagetian concepts. The PXL program supports blind children and children with low ability, intellectual disability and at risk successfully in classification, seriation, and conservation (Campbell et al., 1988; Pasnak et al., 1991; Rhodes et al., 1997). The PXL contains sets of classification, seriation, and conservation problems. These problems consist of the classification of objects according to size, form, texture or orientation, seriation of objects in most dimensions, height, length, width, or overall size. Each problem consists of different objects (Campbell et al., 1988).

The Training Sets of The Orientation, Classification, Conservation: The Orientation Training Set contained 20 problems, and in each problem, there were four identical items and three of the four items were oriented one way and the fourth item was oriented the other way. The Successive Classification Training Set also contained 20 form and 20 size problems. Each problem in each set consisted of four items; one of them differed in terms of form or size. The Conservation Training Set contained 15 problems, each problem was a choice task involving items in two rows (Waiss and Pasnak, 1993).

Piagetian Operations Learning Set: The Piagetian operations learning set consisted of 80 classification (oddity) and 50 seriation problems. Each problem contained different three-dimensional objects like beads, buttons, stones, washers, etc., and two-dimensional drawings (Malabogna et al., 1994).

The Additional Early Mathematics (AEM) Program: The AEM was developed for children with low ability and mathematical difficulties in the 4-7 ages by Van Luit & Van de Rijt in 1995. The AEM program covers Piagetian operations, counting skills, preparatory arithmetic skills, consists of 26 lessons and involves the numbers 1 to 20. Early mathematical competencies are correspondence, classification, comparison, seriation, conversation, counting skills, number symbols, nonnumerical quantity knowledge, and conceptual understanding in the program. The AEM is studied in the daily life context with three and two-dimensional materials, and the program's themes are family, post, party, animals, and shopping (Van de Rijt and Van Luit, 1998).

Constant Time Delay under two conditions: Computer Assisted Instruction and Teacher-Assisted Instruction: The constant time delay is an effective instructional strategy for children with disabilities, involves presenting a target stimulus, followed by a delay period (e.g. 4 seconds) and controlling stimulus (prompt for correct behavior), and this strategy has been used effectively with a computer instruction. Computer-assisted instruction (CAI) is an intervention, which is more effective than teacher assisted instruction (TAI) and is known as traditional instruction in special education (Hitchcock and Noonan, 2000).

Early Numeracy Program: The program name is "Young Children with Special Educational Needs Count, Too!",

developed by Van Luit & Schopman in 1998. The early numeracy program consists of 20 lessons with plans and materials and supports children in learning to count. The program includes teaching early number skills in daily life settings and instructional coaching (Van Luit & Schopman, 2000).

The Learning Set Approach: The learning set approach relies on representing abstract principles, supports children with severe disabilities on concrete operational thinking. This approach has been used to teach classification, seriation, and conservation effectively (Kidd et al., 2008). There were 20 shape, 20 size, 20 type, and 20 orientation problems in the classification (oddity) set, 65 composed of ordinary objects in the seriation set (Pasnak et al., 2004).

Seriation Training with Feedbacks: The training in seriation props children in learning comparison, seriation, counting with concrete materials, pictures, and feedback from the instructor (Kroesbergen et al., 2007).

Computer-Assisted Interventions: (a) The Number Race is a computer game; it supports number skills with representations of magnitudes and counting these representations to connect numbers. (b) *Graphogame-Math* is also a computer game; it supports learning correspondence between objects and numbers, helps children to discover the relationship between number systems and arithmetic. Both games are within one-digit numbers from 1 to 9 (Räsänen et al., 2009).

Early Mathematics Tier 2 Intervention: The intervention is an effective method on mathematics performance of children at risk and is drawn from the Curriculum Focal Points for Prekindergarten Through Grade 8 Mathematics, National Council of Teachers of Mathematics (NCTM). The intervention adresses number concepts and operations, such as counting, basic facts, quantity, place value concepts, part-whole, comparison, classification, seriation, conceptual, and procedural knowledge. The intervention training consists of a presentation of content and systematic instruction (Bryant et al., 2011).

Math Trailblazers: It is the intervention, which was designed to teach mathematics in a science Project. Some activities in the intervention were adapted from the curriculum's task of Math Expressions (Fuson, 2009). The intervention content covers vocabulary (minus, before-after, plus, smaller-bigger, less-more, etc.), number recognition, correspondence, seriation, verbal subitizing, finger use, number plus one principle, number comparison, part-whole, using counting to solve a problem (Dyson et al., 2013).

IEP Workboxes: IEP workboxes is a teacher-friendly intervention strategy, which was designed in preschool programs for children with disabilities (PPCDs). IEP workboxes is based on individual IEP goals. Step I: Creating a workbox for each student, using medium-sized plastic containers labeled with a student's name. Step II: Each student's IEP aims are written on the box cover. Step III: Select the tasks and activities, select an evidence-based instruction. Step IV: The tasks and/or activities are numbered to match the aims written on the cover of the box (Goodman et al., 2011).

Reparative Education Method: Reparative education enhances children with learning disabilities in early number skills. The treatment intervention contains 40 exercises to study the concepts (open-closed, up-down, inside-outside, classification, correspondence, smaller-bigger, adaptation number with object or picture, before-after, one-decimal, light-heavy (Tajar and Shafiri, 2011).

Number Sense Intervention: The intervention involves instructional approaches for lesson activities and training of instructors. The training of instructors includes how to correct errors, the correct use of materials and gestures, how to follow children's engagement and attention. There are 24 lessons in the intervention, which contain counting, number recognition, number comparison, verbal subiziting, finger use, writing numbers, nonverbal calculation, part-whole, story problem, number combination, vocabulary (before, after, plus, smaller, bigger, less, more, altogether, minus) (Jordan et al., 2012).

All of the above-explained interventions were found to be effective in teaching the target skills. The common features of the interventions can be listed as follows: the use of three-dimensional objects, conducting training systematically with lessons consisting of activities, the long-term planning of the training (such as a

semester, an academic year), the use of material sets according to abstract and concrete operations, studying complementary and hierarchical skills.

Instructors in the studies: The individuals who teach the target skills in the studies are usually classroom teachers (Bryant et al., 2011; Campbell et al., 1988; Jordan et al., 2012; Pasnak et al., 1989; Pasnak et al., 1996; Perry et al., 1992; Räsänen et al., 2009; Rhodes et al., 1997; Tajar and Shafiri, 2011; Waiss and Pasnak, 1993; Van de Rijt and Van Luit, 1998). In the some studies, researcher(s)/author(s) (Dyson et al., 2013; Kidd et al., 2008; Malabogna et al., 1994; Pasnak et al., 2004), special education teachers (Goodman et al., 2011; Hitchcock and Noonan, 2000; Pasnak et al., 1995), assistants trained by experimenter (Kroesbergen et al., 2007; Van Luit and Schopman, 2000), and classroom aides (Pasnak et al., 1991; Pasnak et al., 1996) also took part.

Instruction environment in the studies: The instruction environments in which the studies are carried out can be listed as classroom in a public school (Bryant et al., 2011; Campbell et al., 1988; Dyson et al., 2013; Jordan et al., 2012; Kidd et al., 2008; Kroesbergen et al., 2007; Malabogna et al., 1994; Pasnak et al., 1989; Pasnak et al., 1996; Pasnak et al., 1996; Räsänen et al., 2009; Rhodes et al., 1997; Tajar and Shafiri, 2011; Waiss and Pasnak, 1993; Van de Rijt and Van Luit, 1998), special education class in a public school (Goodman et al., 2011; Pasnak et al., 1989; Pasnak et al., 1995; Perry et al., 1992), a room outside of classroom (Pasnak et al., 2004; Van Luit and Schopman, 2000) and a self-contained classroom with teacher, eight students with special needs, an aide, and a nurse (Hitchcock and Noonan, 2000). It is seen that the instructions is generally done in the classroom in a public school. The reason for this may be that the studies are arrangemented mostly in group instruction.

Instruction arrangements in the studies: The instruction arrangements used in the studies can be summarized as group training (Campbell et al., 1988; Jordan et al., 2012; Pasnak et al., 1991; Pasnak et al., 1996; Räsänen et al., 2009; Tajar and Shafiri, 2011; Van Luit and Schopman, 2000; Van de Rijt and Van Luit, 1998), small group instruction (Bryant et al., 2011; Dyson et al., 2013; Kidd et al., 2008; Kroesbergen et al., 2007; Malabogna et al., 1994; Pasnak et al., 1995; Pasnak et al., 1996; Rhodes et al., 1997; Waiss and Pasnak, 1993), one-to-one instruction (Goodman et al., 2011; Hitchcock and Noonan, 2000; Pasnak et al., 1989; Pasnak et al., 2004), and one-to-one and small group instruction together (Perry et al., 1992).

Conclusion

In this review, early number concepts or skills were defined, and their association with future math achievement and the importance of early number development in children with special needs were explained. The main result of this review study is to provide scientific evidence on the importance of Piaget's operations and the role of early number concepts in the number acquisition for the development of early number concepts in individuals with special needs.

In the literature, the concept of matching and sorting can be defined in different ways and there may be confusion in the concept hierarchy during the teaching process. In thie review, *correspondence, classification, comparison and seriation* were defined and hierarchical relationship between them were explained (Baroody et al., 2005). According to the concepts hierarchy first correspondence, then classification, then comparison and last seriation were studied (Baroody et al., 2005; Inhelder and Piaget, 2007; Lemoyne and Favreau, 1981; Platz, 2004; Reys et al., 2009).

This review study was conducted with 22 studies, which met the criteria. Firstly, 50 studies were reached and 28 of them eliminated because they did not meet the criteria. After the first screening, all studies were examined in terms of the inclusion criteria, and the studies were eliminated mostly because of the participants characteristics (typical developing children) and the level of target skills (after number acquisition). Most of the studies on this subject are carried out within the scope of general education. As can be seen in Table 1, when the years and number of studies are taken into consideration, it can be said that there is a limited number of studies on teaching early number skills in

early childhood in special education. The ages of the participants in the studies varied between 3-9, and the majority of them were preschool students. This finding reveals the importance of concepts for young children.

On the other hand, it was observed that classification and seriation skills were frequently studied in the studies (Bryant et al., 2011; Campbell et al., 1988; Kidd et al., 2008; Malabogna et al., 1993; Pasnak et al., 1989; Pasnak et al., 1991; Perry et al., 1992; Pasnak et al., 1995; Pasnak et al., 1996; Rhodes et al., 1997; Van de Rijt and Van Luit, 1998; Van Luit and Schopman, 2000). This may be due to fact that correspondence and comparison skills are often studied in other areas other than mathematics. In the teaching of all basic skills in early childhood, correspondence two objects and comparing them in terms of certain features are the first issues studied. Therefore researchers may have seen these skills as prerequisites and more advanced skills such as classification and seriation may have been stuied frequently.

Another important result of this review is the introduction of effective interventions used in teaching early number skills or concepts to children with special needs in early childhood. One of the main reasons for the difficulties in learning early number skills/concepts by children with special needs is the lack of teaching enriched according to the learning characteristics of individuals (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakemanxya, 2008; Van Luit and Schopman 2000). The studies emphasize the use of effective scientific interventions in teaching mathematics to children with special needs (Kroesbergen and Van Luit, 2003). It is recommended to adopt the principle of concrete to abstract in the process of teaching early number concepts to these individuals, who have difficulty in understanding mathematical concepts, especially because of their cognitive characteristics (Charlesworth, 2011). In other words, children should exhibit their correspondence, classification, comparison, and seriation skills first on concrete objects (concrete), then use pictures or lines (semi-concrete), and finally, perform the symbolic display (abstract) (Bouck, Satsangi, & Park, 2018; Gagnon and Maccini, 2001; Miller et al., 2011). In the studies, activities that were in line with the principle of concrete to abstract were used in interventions as independent variables, and the operation steps of Piaget were taken into consideration and adapted, and effective teaching methods were used. The studies' results in this review showed that interventions were effective in teaching early number skills/concepts to children with special needs. Accordingly, it can be said that the interventions used in the studies addressed in the review are adapted and enriched according to the learning characteristics of children with special needs.

The Piacceleration Instruction, Piagetian Operations Learning Set, The AEM focused on especially Piaget operations (Campbell et al., 1988; Malabogna et al., 1994; Pasnak et al., 1991; Rhodes et al., 1997; Van de Rijt and Van Luit, 1998). Other interventions include also different and various ealry number concepts such as orientation, conservation, counting, conceptual knowledge, part-whole etc. (Bryant et al., 2011; Dyson et al., 2013; Goodman et al., 2011; Hitchcock and Noonan, 2000; Kroesbergen et al., 2007; Jordan et al., 2012; Räsänen et al., 2009; Tajar and Shafiri, 2011; Waiss and Pasnak, 1993; Van Luit & Schopman, 2000). Three dimensional materials, concrete to abstract, simple to difficult approach and hierarchical teaching are common aspects of the interventions. In the acqusition of abstract concepts such as mathematics in early childhood, it can be said that the focus is primarily on development of conceptual knowledge with concrete materials.

In the vast majority of the studies, instructors were teachers (Bryant et al., 2011; Campbell et al., 1988; Goodman et al., 2011; Hitchcock and Noonan, 2000; Jordan et al., 2012; Pasnak et al., 1989; Pasnak et al., 1995; Pasnak et al., 1996; Perry et al., 1992; Räsänen et al., 2009; Rhodes et al., 1997; Tajar and Shafiri, 2011; Waiss and Pasnak, 1993; Van de Rijt and Van Luit, 1998). Considering that much of the time is spent at home in early childhood, parents can be excellent teachers. In the future research, family education and parents can be planned to be trained as teachers.

Considering the limited number of studies in the literature and the years of the studies, the need for conducting studies on the early number development in children

with special needs still continues. The studies included in the review mostly consisted of children at risk at the age of 4 and above, whose native language was not English, with low cognitive ability and/or mathematical difficulties or learning disability. Further studies can be carried out with children with autism, children with intellectual disabilities or different disabilities or children at the age between 0 and 3 years. In teaching early number skills/concepts, it is recommended to use the methods, interventions, and technology-supported interventions, of which effectiveness has been scientifically proved in special education. It is recommended to use other scientific-based interventions in the special education such as video model, role modelling, direct instruction, CRA (concrete-representational-abstract) in teaching the early number concepts in the future research. On the other hand, it is recommended for the future studies to conduct studies with a true experimental reseacrh design, also design with quality indicators. Also, more single subject design studies may be proposed in the future. A social validity study could not be carried out in any of the studies. Therefore, the social validity should be planned for the future research.

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