Early Numerical Intervention Utilizing Ethiopian Gabat'a on Achievement and Motivation of Students with Mathematics Difficulties

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Declaration

I, Kassahun Bogale, hereby declare that the dissertation entitled: ***'Early Numerical Intervention Utilizing Ethiopian Gabat'a on Achievement and Motivation of Students with Mathematics Difficulties'*** is the output of the original research work that I have carried out towards a partial fulfillment of the requirement of the degree of Doctor of Philosophy in Special Needs Education. I further declare that all the materials used to complete this work have been duly acknowledged.

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I, Alemayehu Teklemariam (PhD), here by certify that the dissertation entitled: ***'Early Numerical Intervention Utilizing Ethiopian Gabat'a on Achievement and Motivation of Students with Mathematics Difficulties '*** is an original work carried out by Kassahun Bogale towards fulfilling of the partial requirement of the degree of Doctor of Philosophy in Special Needs Education. The dissertation has been submitted for final evaluation to the University with my approval.

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This is to certify that this dissertation report is orchestrated by Kassahun Bogale, entitled: Early Numerical Intervention Utilizing Ethiopian Gabat'a on Achievement and Motivation of Students with Mathematics Difficulties, and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Special Needs Education complies with regulation of the university and meets the accepted standards with the originality and quality.

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Early Numerical Intervention Utilizing Ethiopian Gabat'a on Achievement and Motivation of Students with Mathematics Difficulties

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Abstract

In the field of mathematics difficulties, there is an often-noted lack of researches. The present study investigated the effect of concrete fading numerical intervention utilizing gabat'a on early numerical achievement and early mathematics motivation of primary school students with MD. Gabat'a, the Ethiopian indigenous math game, has six holes, two storages, and stones/beads for playing in pair.In the present study, it was organized for dual purposes: for instruction and game. Children with MD exhibit multifaceted problems in comparison with their counter parts. These lead them to have long-term educational problems. At 3 sites, 72 students with MD were screened using BANUCA and other screening tools. A method of quantitative experimental research utilizing pretest-posttest control group design was used in tandem with MANCOVA to analyze the data. The design used stratified randomization, taking gender, difficulty type, prior mathematics knowledge as a strata and then randomly allocated into: Experiment 1 entailed two groups, CIGO and control group; and experiment 2 involved three groups, AIGG, AIGO, and control group. The interventions occurred in total for 18 week, 3 sessions per week and 45–60 min per session. Then, a MANCOVA result shows that students with MD in both experiments exhibited significantly higher performance than control group on counting and number concept achievement, arithmetic achievement, and early mathematics motivation. However, students with MD in AIGG condition did not show significant performances than that of AIGO condition. In addition, the findings indicated that mostly gender, difficulty type, and prior mathematics knowledge did not play significant roles in achievement and early mathematics motivation. With respect to correlational results, within the addition and subtraction constructs, the correlation was highest, similar results were found in cross correlation as well. The multiple regression findings indicated that addition had a unique significant contribution for subtraction than counting. Moreover, a canonical correlation shows that early mathematics motivation positively influenced achievement of counting and number concept, but not for arithmetic. To recap, the CRA sequence utilizing gabat'a is effective in teaching early numeral interventions for students who struggle in mathematics. This pattern of instructional intervention could be, robust techniques of counting and number concept and arithmetic teaching in the future, which integrated with classroom activities if teachers want to increase students' early numerical performance and early mathematics motivation. Practical implications, limitation of the study, and suggestions for future research in this area are provided.

Keywords: concrete fading strategy, gabat'a, achievement, motivation, MD

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Acronyms and Lists of Abbreviations

BANUCA	Basic Numerical and Calculation Ability
EGMA	Early Grade Mathematics Assessment
AIGG	Arithmetic Instruction Using Gabat'a as an Instruction and Game
AIGO	Arithmetic Instruction Using Gabat'a Only for Instruction Without Game
CIGO	Counting and Number Concept Instruction using Gabat'a Only for Instruction Without Game
MD	Mathematical Difficulties
MoE	Ministry of Education of Ethiopia
MDRD	Mathematical Difficulties/ Reading Difficulties
SLD	Specific Learning Disabilities
LD	Learning Disabilities
IDEA	Individuals with Disabilities Education Act
EMMS	Early Mathematics Motivation Scale
CNC	Counting and Number Concept
CRA	Concrete Representational Abstract
PMK	Prior Mathematics Knowledge
MLC	Minimum Learning Competency
ASSPS	Assessment of Students with Special Needs in Primary Schools
SNEds	Special Needs Educations
KG	Kindergarten
SDT	Self Determination Theory

Chapter One

Introduction

1.1.Background of the Problem

Be acquainted with mathematics, it is an indispensible part in all areas of life and accounts for variance in successful functioning in school, at home, on the job, and in the community. To appreciate the computerized world and match with the newly developing information technology, familiarity with mathematics is undeniably critical. So, a robust conception of number and the quantity it represents is very important and it is an integral part of basic mathematics knowledge acquisition and daily activities. However, learning these basic early mathematical concepts is enormously challenging and difficult for multitude numbers of children (Dowker, 2019; Jordan, Hanich & Uberti , 2003). Jordan, Hanich, and Kaplan (2003), and Geary (2004) have emphasized that persistent deficits of early numeral competency and arithmetic combination among primary school students are associated with mathematics difficulties (MD). As per IDEA 2004 (U. S. Department of Education, 2004), MD is a disorder of one of the psychological processes of learning disabilities, which is the imperfect ability to do mathematical calculations. The terms mathematics difficulties or early numerical concepts and skills deficits is referred to as MD, in the entire bodies of this research. MD has been considered as a ‘Specific Disorder of Arithmetical Skills’ (Hein et al., 2000). It is specific not global impairment and is not explicable in terms of the general intellectual disabilities or of inadequate schooling (DIMDI, 2015).But, rather, it refers to the issues or problems that the child encounters in the process of learning, in terms of .listening, mathematical problem solving, and calculation etc. Previous studies have been found that children with MD exhibit multifaceted problems viz., arithmetic fact retrieval (Butterworth, 2004; Mazzocco et al., 2008), lack of motivation of learning (Sideridis, 2003), and extremely low achievement in comparison with their counter parts. In turn, this leads to future educational challenges.

The occurrence of MD is a big problem and it is estimated that up to 6% or more of the school-age population have severe and specific MD (Talepasand & HanifiVahed, 2012) and occurs as a co-morbidity about 40% of individuals with reading difficultie (Ackerman & Dykman, 1995). For rendering special education services in one school, only about 5% to 10% of school-age children are usually identified as having MD (Fuchs et al., 2007a). Nevertheless, this figure may drop or rise, depending on definition and the assessing instruments of MD.

The prevalence rate of MD can be diminished by preventing MD through providing evidence-based intervention at an early age that can ameliorate early mathematics deficits (Fuchs et al., 2005) and are paramount important (Gersten et al., 2005). Similarly, from various related studies, for example, Berch and Mazzocco (2007) and Gersten et al. (2005) pointed out that getting early intervention plays a prominent role in terms of preventing significant difficulties for many learners; and for children to be successful with basic mathematical computations in the early grades, number sense and number combination are one of the most important skills necessary for them (Berch, 2005). Moreover, it is believed that a firm understanding of numbers and number combination is central to math learning and that instruction includes number sense activities (Griffin et al., 2016).

Despite having a dearth of empirical research about the effect of mathematics intervention and instruction sequence using board game on learning in formal school settings to guide future research and practice; research findings and intervention syntheses offer evidences about instructional approaches that best address the needs of students who are at risk of MD, and insight into practices and materials that hold promise for teaching them. Remarkable suggestions from prior studies have been rendered for intervention for students with MD, including computer-assisted instruction (Seo & Woo, 2010) which provides additional support in meeting individual students' with MD needs in the inclusive classroom (Seo & Bryant, 2012), peer-assisted tutors (Baker et al., 2002), verbalizations of cognitive strategies (Fuchs & Fuchs, 2001), explicit instruction (Gersten et al., 2009), game based instruction (Wan Ahmad et al., 2010), mnemonic strategy instruction (Manalo et al., 2000), schema-based instruction (Jitendra et al., 2002), cognitive strategy instruction (Montague & Dietz, 2009), representations (Jitendra et al.,2016), and the concrete–representational–abstract (CRA) instructional framework (Kim, 2020; Hinton &Flores, 2019).

The recent experimental studies on students with MD support the use of CRA instructional framework with explicit strategic instruction. For instance, Ching and Wu (2018) enacted pretest–posttest control group design and it was found that concreteness fading fosters children's understanding of the inversion concept in addition and subtraction for student without MD; and Hinton and Flores (2019) implemented a multiple baseline across behaviors design for two students who were at risk for mathematics failure and they found that students improved their performance across each of the mathematical concepts taught using the CRA sequence.

Similar to the present study, Ching and Wu (2018), Xin et al.(2017) used a pretest–posttest comparison group design with random assignment of participants to groups and the finding indicates that there is a potential effect of the explicit intelligent tutor-assisted intervention in reference to the traditional teaching program for students with MD. Notably, moreover, explicit instruction using the CRA sequence is effective in teaching mathematics interventions for students with MD because it first addresses conceptual knowledge, providing students with the experiences needed to make meaning of numbers and operations using objects, pictures, and drawings (Flores et al., 2014). This conceptual knowledge provides context through which students can understand and develop procedural knowledge, then proceed to accuracy and fluency (Miller et al., 2011).

Moreover, as reported in their serious gaming field experimental study (Bottino et al., 2014), instructional game is also recommended as an effective ways of improving learners' mathematics achievement and promoting their motivation. Ku et al. (2014) added that game based learning is more effective than pencil paper based (traditional) learning processes and the students feel more comfortable and their performances enhance in mathematics courses. With respect to effectiveness of linear board game, an experimental study of typical developing students indicated the effectiveness of engaging students through board games on their academic performance as studied by Viray (2016). According to Bell and Cornelius (1988), gabat'a was the most prominent indigenous mathematical board game that was being played in Ethiopia in different cultures, having its own rules via following the orderly processes of science. Similar research by de La Cruz et al. (2000) demonstrated that teachers found such game to be beneficial to students with MD. It is stressed that such similar board game, in general, helps to use concrete experiences before teaching students abstract concepts (the concrete-semi-concrete-abstract sequence) (Mercer & Mercer, 1998), this strategy affords teachers the opportunity to provide a wide range of choices. Specifically, the game was found to improve basic math concepts such as adding, subtracting, counting and estimation and also it facilitated memory, observation, concentration, and encouraged positive social interaction (de La Cruz et al., 2000). It is suggested that integration of the games into schools could help reform the educational system. Sutherland and Dennick (2003) mentioned that people acquire new knowledge and complex skills from game play, suggesting gaming could help address one of the nation's most pressing needs and strengthening the system of education. Therefore, the present study utilized these competing instructional methods as a part of intervention strategies in combination with CRA. That is, CRA together with explicit instruction using Ethiopian indigenous mathematical game, gabat'a, as instructional aids or a game were enacted to see if they have effect on the learner's early numeral achievement and early mathematics motivation.

As per Pintrich (2003), experts in education explicated that having learning motivation is paramount important for academic achievement and persistence. Ayub (2010) investigated the relationship between intrinsic and extrinsic motivation on the academic performance. The findings in Ayub's study supported the significance of motivation to academic performance. Besides, specifically, identifying predictors of performance in the early grades should be applicable towards efforts at early identification, especially to the extent that math difficulties occur on a continuum. For instance, counting skills appear most proximal to arithmetic and therefore may be more predictive of math outcomes than are other number predictors (Martin et al., 2014). In the present study, such similar relation was assessed through co-rrelational study. The association between a separate measure within mathematics achievement components outcomes and motivational orientations components was investigated.

On this continuum, gender differences of MD, difficulty type, and PMK in terms of early numerical achievement and early mathematics motivation are salient concerns. Past and recent studies indicated that the gender prevalence of MD on CNC and arithmetic performance and early mathematics motivation have not been invariant (Ashcraft, 2002 ; Devine et al., 2013). Whereas, the mathematics achievement and motivation gap between MD and MDRD children are wide and persistent (Powell et al., 2011). One prior research has shown performance differences on number combinations; MD-only students out performed MDRD students (Andersson, 2008). Considering PMK, Rajkumar and Hema (2017) show that a student's prior knowledge and previous experiences with mathematics are the best predictors of future success. These instructional experiences can have a significant impact on the achievement and motivation of students with MD.

The theoretical underpinning of the relevant elements of the present study is explicated later in the next section. The predominant theory that guides this study is Bruner children's cognitive development theory and ideas that shape this framework. But, this theory was made partially to work in tandem with Piaget's cognitive development and Vygotsky's socio-cultural theory. Utilizing these theoretical matrixes, students with MD are enormously benefited via the CRA instructional frame-work (Agrawal & Morin, 2016) in combined with explicit instruction (Gersten et al., 2009; Powell, 2015) and game play.

In the present dissertation study, it was taken an experimental methodological approach to understand about whether the concrete fading instructional intervention has impact on early numeral achievement and early mathematics motivation as a function of gender, the two difficulty type, and PMK. After identifying MD students, they were randomly assigned by stratifying to conditions. The study investigation was carried out using pretest–posttest-control group design. On the top of that some descriptive survey on assessing the demographic characteristics, and correlation study to investigate the relation among key variables were conducted.

To wind up, it was investigated the patterns of performance on early numerical skills and early mathematics motivation to gain insight into the effectiveness of concrete fading numeral intervention for students with MD. Studying the pertinent aspects including the identification, assessment and intervention for students with MD by applying rigorous theories and methods are a springboard to the study of children with MD. In line with this, the context of the study is briefly presented together with stating of the problem; the methodology of the experiments and the main intervention protocols are presented, further ways of data analysis and main findings are outlined.

1.2. Statement of the Problem

This line of research, learning disabilities as a body and MD in specific, is limited in the globe and extremely little in Ethiopia. However, in the other areas of learning disabilities, that is reading difficulties, the work of Yirgashewa and Therrien (2016) on the impact of instructional intervention on students at risk of reading difficulties in Addis Ababa gave insight for this study along with some other empirical researches made by Alex de Voogt et al.(2018), Powell (2015), and Hinton and Flores (2019). This elegant Amharic reading instruction experimental work in tandem with the other related researches shape the conceptual framework and the methodological aspects of the study.

Apparently, reviews show that the gaps are enormously wide in Ethiopia, a lot of work is in front, and further investigation is deemed necessary from mainly in the perspective of gauging a holistic pattern of MD, beginning from its nature, prevalence, identification, assessment, and intervention. A pertinent starting point as an initial study was to ascertain first the ways and the possibility of identifying children with MD in different schools. Interestingly, the Ministry of Education of Ethiopia (MoE) designed Basic Numerical and Calculation Ability (BANUCA) as a screening tool for MD (Räsänen & Natayi, 2011). Using this tool together with some others was a potential path to accomplish the screening process. Following this path, assessment and intervention of children at risk of MD were carried-out.

Research has shown that people with LD clearly represent a significant section of the society. Specifically, the prevalence of MD is a big problem, and from the school-age population, it is estimated that up to 6% or more of have severe and specific MD (Talepasand & HanifiVahed, 2012). Studies in different countries showed similar trends on the prevalence of MD, such as Canada, 3.3% (LDAC, 2006) ; India, 10.5% (Mogasale & Patial, 2012); and Nigeria, 18% (Orim & Uko, 2017). The dearth of accurate data on prevalence of specific learning disabilities is a global concern. This problem occurs in Ethiopia as well since finding realistic data on incidence of SLD is challenging, owing to lack of operational definition, heterogeneity of the disability and identification/assessment criteria.

A review of research and theoretical literature to identify specific difficulties associated with learning disabilities in mathematics revealed that children with MD exhibit a problem of arithmetic fact retrieval (Butterworth, 2004; Mazzocco et al., 2008), lack of motivation of learning (Sideridis, 2003), and extremely low achievement in comparison with their counter parts. To mitigate the problems, the areas of needs for intervention are wide array of early numerical competencies, such as number competency, AR fluency, multiplication and division, place value, word problems and, etc (Chinn, 2015; Emerson & Babtie, 2014). On account of various constraints, these wide arrays of needs were not covered in this dissertation period. Thus, the intervention was carried on CNC competency and arithmetic fluency. Only CNC and arithmetic are opted since they predict later mathematics growth, achievement, and motivation.

Moreover, in the absence of effective interventions, many children with mathematics delays stay behind throughout their school careers (Morgan et al., 2009). These lead to long-term educational problems. Specific to teaching students how to solve numerical problems, preliminary researches have been rendered suggestion for instructional intervention for students with MD, viz., computer-assisted instruction (Seo & Woo, 2010) , peer-assisted tutors (Baker et al., 2002), verbalizations of cognitive strategies (Fuchs & Fuchs, 2001), explicit instruction (Gersten et al., 2009), game based instruction (Wan Ahmad et al., 2010), mnemonic strategy instruction (Manalo et al., 2000), schema-based instruction (Jitendra et al., 2002), cognitive strategy instruction (Montague & Dietz, 2009), representations (Jitendra et al.,2016), and the concrete–representational–abstract (CRA) instructional framework (Kim, 2020; Hinton &Flores, 2019). Perhaps, it is difficult to meet diverse learning needs when teaching complex problem-solving skills when using only one isolated approach. It is possible that a combination of strategies might result in more positive outcomes for students. Thus, research is needed on an integrated instructional approach that combines what is currently known about best practice approaches for teaching CNC and arithmetic skills. In this respect, students with MD gain advantage of utilizing the CRA instructional frame-work (Agrawal & Morin, 2016) by integrating explicit instruction (Gersten et al., 2009; Powell, 2015) and game play. Combining CRA with explicit instruction using Ethiopian indigenous mathematical game, gabat'a, as instructional aids or a game were were used to investigate whether this integrated instructional approach has effect on the learner's early numeral achievement and early mathematics motivation or not.

The lack of available materials for numerical intervention creates problem for teaching and learning process which negatively affects effective teaching (Matimbe, 2014). According to Gezahegn (2007), in Ethiopia, despite giving due attention to the education by the government, the schools don't get enough budgets to fulfill the basic needs of the schools. Teachers faced challenges to concertize the mathematics lesson utilizing simple additional teaching materials, such as protractors, solid figures, rulers etc in schools. The absence of the materials resources make the teaching and learning of mathematics more problematic to the students and teachers as they are forced to deal with only theoretical aspect and can't learn in a more concrete way. Similarly in African countries, the World Bank studies found that the deficiency of teaching materials and textbook persists especially in primary schools(Marope, 2005). Inadequate instructional materials, such as student workbooks, teaching aids and enrichment materials are the challenges of the schools. The current study works to investigate the efficacy of incorporation of the indigenous knowledge systems in the learning of mathematics for students with MD in primary school. The indigenous Ethiopian math board games such as gabat'a is being enormously useful for students with MD in far rural areas of Ethiopia and other developing countries since gabat'a can be made out of local materials or simply arranging gabat'a by pitting 12 small holes on the ground and putting four small stones in each hole.

In Ethiopia, it is also still enormously little known about disparities in gender, difficulty type, and PMK of mathematics achievement in terms of early numerical achievement and early mathematics motivation of children at a risk of MD. Past and recent studies indicate that there is a stereotype that women score less than men when they take math exam (Ashcraft, 2002), though the findings are inconsistent. Recent studies conclude that girls and boys have similar levels of math performance in both primary and secondary schools. Besides equal number of girls and boys are affected by MD (Devine et al., 2013). Concerning motivation, Guay et al. (2010) illustrated the effects of gender on motivational components were observed, showing that girls are more intrinsically motivated towards reading and writing and are more regulated by identification towards writing than boys. In contrast, boys are more intrinsically motivated towards maths than girls. These results parallel to those of other studies (Eccles et al., 1993), and indicate that gender stereotypes may affect motivation processes in the early grades. Similarly, in Ethiopia, plenty of researches have been done so far in regular schools, revealing typically developing boys outperformed mathematics achievement than girls in elementary schools (Dickerson et al., 2015). With respect to the difficulty type, the gap between MD and MDRD in term of students' mathematics achievement and motivation is spacious and invariant (Powell et al., 2011). Some prior researches indicate the performance differences on number combinations between students with MDRD and MD-only (Andersson & Lyxell, 2007), showing up MD-only students outperformed MDRD students. Respecting PMK in mathematics, Rajkumar and Hema (2017) indicated that a student's PMK and previous experiences with mathematics are the best predictors of future success. These instructional experiences can have a significant impact on students' achievement.

In the present study, the approaches of teaching and game have impact on both students' with MD performance in CNC, arithmetic and early mathematics motivation. The association between a separate measure within mathematics achievement components' outcomes and motivational orientations components was investigated, through co-rrelational study. Bottino et al. (2014) carried out a gaming field experimental study and recommended that instructional game is an effective ways of improving learners' mathematics achievement and promoting their motivation. Additionally, in comparison with pencil paper based (traditional) learning processes, game based learning is highly effective and the students feel more comfortable and their performances enhance in mathematics courses (Ku et al., 2014). An experimental study of typical developing students by Viray (2016) indicated that engaging students through board games is efficacious on their academic performance. Moreover, as far as can be determined, there is very little study, specific to the present study, examining the possible correlation among motivation, counting, addition, and subtraction. This study also aims to fill this gap.

The areas of needs for intervention are wide array of early numerical competencies, such as number competency, arithmetic fluency, multiplication and division, place value, word problems and, etc (Chinn, 2015; Emerson & Babtie, 2014). On account of various constraints, these wide arrays of needs were not covered in this dissertation period. Thus, the intervention was carried on CNC competency and arithmetic fluency, through CRA with explicit instruction using gabat'a in tandem with game and without game. Only CNC and arithmetic achievement are opted since they predict later mathematics growth, achievement, and motivation. The group intervention was conducted via enacting pretest-posttest-control design. Thoroughly, assessing the students' gap through BANUCA and pretest result was implemented. Considering these, research questions and hypothesis were formulated.

1.3.Basic Research Questions

This dissertation study sought to answer two major research questions, experimental and co-rrelational. The first experimental research question dealt with CNC whereas the second research question focused on arithmetic. These two research questions were more or less similar, in terms of the experimental trends, procedures, interventional strategies, and research participants. It is unusual to utilize correlational study in tandem with experimental study. However, most recently, it is possible to apply a correlational design in a repeated experimental study (Srinivas and Chakrabarti, 2017).

1.3.1. Experimental Research Questions

1. What are the effects of concrete fading intervention strategies using gabat'a, Ethiopian indigenous math board game, on CNC achievement and early mathematics motivation of students with MD?

- Is concrete fading intervention strategies embedded with gabat'a, Ethiopian indigenous mathematics board game, as instructional aids (CIGO) efficacious on CNC achievement and motivation, in comparison with that of control group (CG)?
- Is there any interaction effect between those CNC interventional approaches [using gabat'a for instructional purposes (CIGO), and control group (CG)] as Groups, and Time (pretest and posttest)?
- Do gender, PMK in mathematics, and difficulty type have main effect on the CNC achievement and early mathematics motivation across conditions (CIGO and CG) and Time (pretest and posttest)
- Is there any interaction effect among conditions (CIGO and CG), time (pretest and posttest) with either of gender, PMK in mathematics, and difficulty type on the students' CNC achievement and motivation?

2. What are the effects of concrete fading intervention strategies using gabat'a on arithmetic achievement and motivation of students with MD?
   - Is concrete fading intervention embedded with gabat'a, Ethiopian indigenous mathematics board game, as an instructional aid and game (AIGG) efficacious on arithmetic achievement and early mathematics motivation, in comparison with that instruction by gabat'a with-out game (AIGO) and control group (CG)?
   - Is there any interaction effect between those arithmetic intervention approaches (using gabat'a for both instruction and game, AIGG; only for instructional purpose without the gabat'a game, AIGO; and CG) as Groups and Time (pretest and posttest)?
   - Do gender, PMK in mathematics, and difficulty type have main effect on the arithmetic achievement and early mathematics motivation across conditions (AIGG, AIGO and CG) and Time (pretest and posttest)?
   - Is there any interaction effect among conditions (AIGG, AIGO and CG) and time (pretest and posttest) with either of gender, PMK in mathematics, and difficulty type on the students' arithmetic achievement and early mathematics motivation?

1.3.2. Co-relational Research Questions

3. What is the relationship among achievement of counting, addition, subtraction, and early mathematics motivation?

- Is there a correlation cross and within each subtest of CNC, arithmetic, and early mathematics motivation?
- Does counting predict addition and subtraction?
- Does skill of addition facilitate subtraction?
- Can motivation toward CNC, addition, and subtraction predict students' early numerical achievement?

1.4.Hypothesis

Based on investigation of the review of related literature, the researcher comes up with the following testable hypotheses that were tested at 0.05 significant levels for the study. The hypothesis is arranged in three categories in terms of the experimental one , two , and co-relational research questions.

1.4.1. Experimental One Hypotheses of Counting and Number Concept

H_1. Students at the risk of MD who follow concrete fading intervention embedded with gabat'a, Ethiopian indigenous mathematics board game, as an instructional aid only (CIGO) hold significantly higher score on CNC achievement and motivation, in comparison with those follow conventional approach.

H_2. There is significant interaction effect between those concrete fading intervention approaches (using gabat'a for an instruction aids only, CIGO; and conventional approach, CG) as Groups, and Session time (pretest and posttest).

H_3.There is a significant difference effect on the CNC achievement and motivation across gender, PMK in mathematics, difficulty type in the two instructional approaches.

H_4. There is a significant interaction effect between conditions (CIGO and CG), session time (pretest and posttest) with either of gender, PMK in mathematics, and difficulty type on students' mean scores on CNC achievement and motivation.

1.4.2. Experimental Two Hypotheses of Arithmetic

H_5.Students at the risk of MD who follow concrete fading intervention embedded with gabat'a, Ethiopian mathematics board game, as an instructional aid and game (AIGG) hold significantly higher score on arithmetic achievement and motivation, in comparison with those who get instruction by gabat'a with-out game (AIGO) and also those follow conventional approach.

H_6. There is significant interaction effect between those concrete fading intervention approaches (using gabat'a for both instruction and game, AIGG, and only for instructional purpose without the gabat'a game, AIGO, CG) as Groups, and Time (pretest and posttest).

H_7. There is a significant difference the main effect on arithmetic achievement and motivation across gender, PMK in mathematics, difficulty type in the three instructional approaches.

H_8. There is a significant interaction effect among conditions (AIGG, AIGO and CG), Time (pretest and posttest) with either of gender, PMK in mathematics, and difficulty type on students' mean scores on arithmetic achievement and motivation.

1.4.3. Hypotheses on Correlation

H_9. There is significantly high correlation cross and within each subtest of CNC, arithmetic, and early mathematics motivation.

H_{10}. Counting skills significantly predict addition and subtraction.

H_{11}. There is significantly high relationship between addition and subtraction.

H_{12} . Motivation toward CNC, addition and subtraction significantly predict student mathematics achievement.

1.5.Theoretical Framework

Three theoretical frameworks were considered when designing this study. The present study is dominantly anchored on Bruner children's cognitive development theory and ideas that shape the theoretical framework. However, Piaget's cognitive development and vygotsky's socio-cultural theory are embedded within it. The CRA sequence of instruction was originally proposed by Bruner and inspired mathematics education research on children with MD (Miller & Hudson, 2007) and it is also called Bruner's CRA in early childhood education or special education (Hwang, 2012). As per Bruner (van den, 2014), three forms of children's cognitive development are processed:

(1) an enactive or concrete form, in this case, students can acquire mathematical concepts through physically manipulating concrete objects.

(2) an iconic or representational form, in which they learn to represent a mathematical concept in a graphic or pictorial form; and

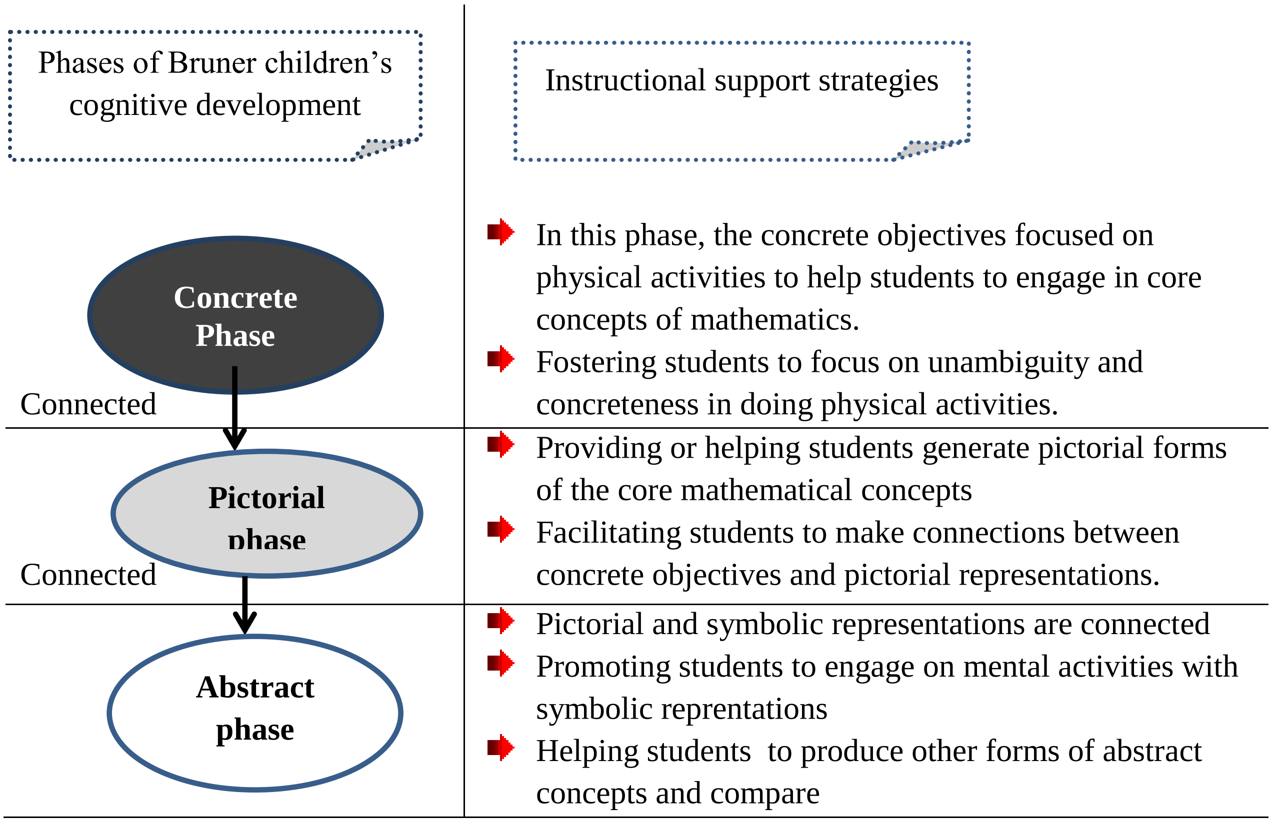
(3) an abstract or a symbolic form, by representing a concept with an abstract model or symbols, they learn mathematical concepts and operation.

These three forms can be illustrated with examples, the quantity four can be represented by four blocks or four apples physically (concrete) and the quantity four can then be represented by four dots in a graphic form or as graphic bars on a number line, which is still concrete but more abstract than the physical forms. Ultimately, the quantity "four" can be represented by a mathematical symbol, the numeral 4. Therefore, Bruner theoretical instructional strategy plays an important role for those students in engaging in mathematics by extracting key mathematical concepts and eventually in developing abstract concepts by generating multiple representations, comparing those representations and analyzing them **(**Kim, 2020). Despite having the core principles for teaching mathematizing, it fails to render specific strategies for teachers to apply and implement it in their classroom practice. According to Kim (2020) till now clear suggestions on how to provide the connections between phases (a connection between the concrete phase and the pictorial phase, or a connection between the pictorial phase and the symbolic phase) had not been provided, but studies on CRA such as Fyfe et al. (2015)or Flores (2010) provide evidence of how concrete and pictorial representations help students to develop mathematical concepts better. However, Kim (2020) utilized CRA theoretical framework that supports to enact connection between the concrete to representational to abstract phases in mathematical teaching and learning teachers to implement the ideas of mathematizing. Figure 1 depicts the framework and features of connections in relation to the current study.

Moreover, the CRA framework uses explicit instruction, which is recommended mathematics pedagogical approach for students with disabilities (Gersten et al., 2009; Powell, 2015). Within the CRA instructional framework, each lesson involves explicit instruction (Doabler & Fien, 2013). Hence, the present study is entirely pivoted on Bruner's CRA frame work with explicit instruction. Since utilizing gabat'a as an instructional aids for students with MD in mathematics classroom is highly compatible to implement Bruner's CRA frame work with explicit instruction. This was done through rearranging gabat'a into *physical gabat'a as a concrete (C) (*see Figure 7*) , mental gabat'a as representational (R)(see* Figure 9*), and most efficient min counting strategy and verbal counting strategy as an abstract (A).*

Figure 1

Concreteness Fading Strategies in the Phases of Concept Development



Adapted from Kim (2020)

By implementing these strategies, teachers can help students to focus on the core structures of mathematical concepts, which is a stepping-stone to the symbolic phase of concept development. With respect to the other embedded theories, like the study of Juliana and Hao (2018) that focused on effect on abacus on the addition and multiplication performance; Piaget's Theory of Cognitive Development (Woolfolk, 2016) espouses four stages of development wherein the preoperational and concrete operational stages (COG) have a significant role in instruction using gabat'a. The former entails the ability of children to relate objects and symbols, whereas the latter deals with children's ability to think logically and reversely. Relating to this study, the preoperational stage familiarizes children with the beads (stones) of the gabat'a and how they represent actual amounts and numbers, paving the way for numerals to be coded in their memory as a certain number of beads. Meanwhile, when children progress to the concrete operational stage, development of the mental gabat'a leading towards mental arithmetic takes place (imagination of gabat'a).

In addition, considering Vygotsky's Social Constructivist Theory, Alex de Voogt et al. (2018) mentions cultural tools as a means of learning mathematics for children. The traditional math board game whose existence has been documented as early as 1500 B.C and is found in varied forms throughout Africa and Asia (Natsoulas, 1995). This board game, mancala and sungka in other countries and gabat'a in Ethiopia, is purely mathematical and the method of playing follows the orderly processes of science. Specifically, the game was found to improve basic math concepts such as adding, subtracting, counting and estimation. Additionally, it facilitated memory, observation and concentration, and encouraged positive social interaction. To strengthen this, Alex de Voogt et al. (2018) indicated that adapting the board game (mancala), it plays a role for teaching early mathematical concepts, counting, addition, and subtraction.

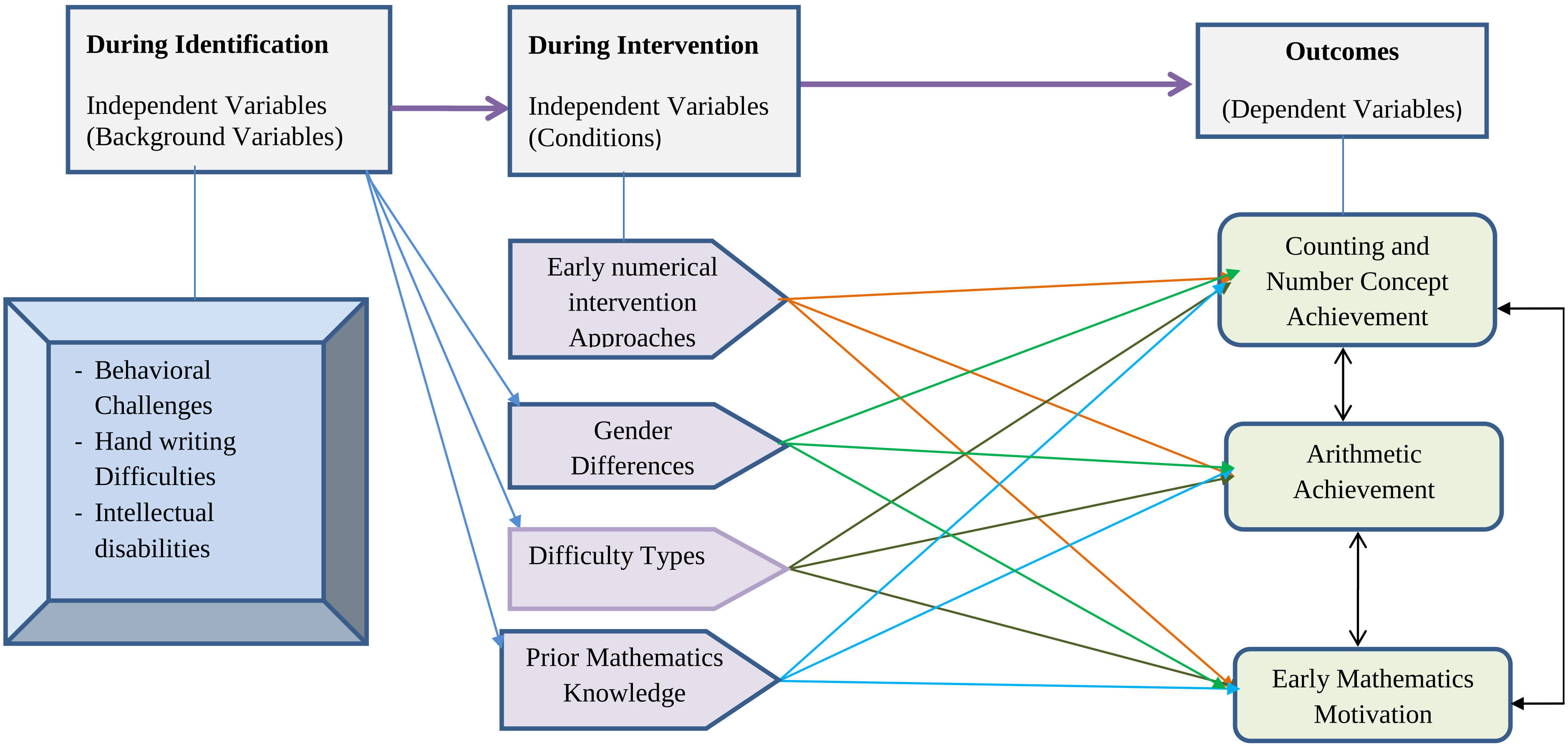
Moreover, Gersten et al.(2009) and Powell (2015) recommended that the CRA instructional framework with explicit instruction is mathematics pedagogical approach for students with disabilities. Explicit instruction involves a sequence that moves from the teacher modeling the mathematical concept, to teachers guiding (i.e., cuing or prompting) students through the various steps of a mathematics problem to finally transitioning students to solve problems independently (The National Mathematics Advisory Panel, 2008). Within the CRA instructional framework, each lesson involves explicit instruction (Doabler & Fien, 2013).

1.6.Conceptual Framework

Keeping both conceptual and theoretical framework is essential in terms of testing and informing every aspect of data collection and analysis/ interpretation of the study (Maxwell, 2013). The conceptual framework is gleaned from a variety of experimental research review of the literatures that used in various studies related to the effect of different interventions on children at risk of MDs' mathematics achievement, motivation, etc. (Lim et al., 2006; Cameron & Dwyer, 2005). Besides, to build the conceptual framework for this study, the above theoretical framework plays a prominent role. From the bigger picture of the literature and theoretical views, various variables can be entertained, however, only the most salient variables are considered for this study. In comparison with other peers, multifaceted problems are exhibited by children with MD, such as arithmetic fact retrieval, basic counting and number processing, non-numerical deficits, lack of motivation of learning, and extremely low achievement, etc. These all variables are considered as dependent variable, some of them are mentioned in Figure 2.

Figure 2

Conceptual Framework of the Association among Salient Variables



On the other hand of the continuum, to intervene these all problems, it is deemed necessary to enact manifold intervention. As it is apparently aforementioned, various instructional methods are pertinent to make children with MD to work on mathematics. Despite those, CRA with early explicit mathematics instruction with game and with-out game are the most pertinent approach of intervening students with MD for this study. Instructional approaches, difficulty status, gender differences, prior knowledge in mathematics (PMK) are taken as independent variables to observe changes on dependent variables. To do so, experimental pretest and immediate posttest were enacted. Dependent variables are: (a) mathematics achievement and (b) early mathematics motivation. Students with MD having behavioral challenges, hand writing difficulties, and intellectual disabilities are discarded since these background variables have potential effect on the outcome. The comparison and relation between these variables are depicted in the following fashions (see Figure 2).

1.7. Significance of the Study

The importance of this study is multifold. The followings are some of them:

First, very little has been written about the effects of concrete fading early numerical intervention utilizing Ethiopian gabat'a on achievement and motivation of students with MD in Ethiopia. The study, therefore, can be seen as one contribution in the area, where scanty information is available. Conspicuously, several will be benefited starting from students who would like to work on the areas, researchers, policy makers, and other relevant bodies, using it as a reference materials for the development of mathematical intervention protocols for students at risk of MD and reading more on the area.

Second, skills acquisitions, students with MD acquire skills of CNC competency and arithmetic fluency through the instructional approaches with game and without game. The schools, teachers, parents will gain skills via training, observing and practicing the skills to teach other students for the next time.

Third, replication, it will have practical relevance for designing and implementing strategies of instructional interventions for students with MD at all primary schools levels in Ethiopia.

Fourth, outcomes of this research are intended to better provide empirical data with intervention and directions for action for government organizations, NGOs, private organizations, associations that work in the area of inclusive education as a whole and MD in specific.

Fifth, technological aspect, like other board game, gabat'a can be enacted in computer technology as a game and a teaching aids, since it is more effective with regard to mathematics achievement in special needs students than in general education students, and a reasonable use of computers can provide mathematics exercises tailored to individual needs, and adaptive software can identify child's strengths and weaknesses to fill possible gaps.

Lastly, the finding of the study could also contribute to continue research in the field of learning disabilities in general and MD in particular.

1.8.Delimitation of the Study

This study is delimited in terms of time, location, population, or environment (including both physical and social conditions) and scopes. First, in this dissertation time-line, the researcher focused on two instructional intervention paradigms in two content areas among the others, CNC competency and arithmetic fluency. Its effect was seen in two outcome variables viz., early numeral mathematics and early mathematics motivation based on instructional approaches, session time (pretest and posttest), gender, difficulty type, and PMK in mathematics as independent variables. It was also demarcated in three governmental primary schools in Addis Ababa and the sample was entirely first grade students with MD and MDRD.

1.9.Operational Definition of Terms

As stressed by Kerlinger (1986), an operational definition ascribes meaning to a term according to specific operations used to measure it. Typically, researchers define all variables contained in research questions or hypotheses.

Mathematical difficulties: those students in grade one who score lower than 30 percentile in the BANUCA, for instance, low performance (between 20 to 30 percentile) and finally extremely low performance with further analysis recommended (below 10 percentile).

Counting and number concept: it is content under early numerals having two sub areas: Conceptual counting and procedural counting , and number identification and quantity discrimination. All the responses are taken and scored out of 168.

Arithmetic: it has four sub areas: adding (dot and symbolic) and subtracting (dot and symbolic) numbers and scored each out of 15 marks from the achievement test.

Early mathematics motivation: refers to an internal state that allows people to work toward certain goals. It is gauged the components of early mathematics motivation namely; intrinsic motivation, identified regulation, and controlled regulation collectively via early mathematics motivation scale and their score were recorded accordingly.

Arithmetic instruction with gabat'a game (AIGG): in this first experimental group, students take all the lesson contents of addition (dot and symbolic) and subtraction (dot and symbolic) using concere fading strategy gabat'a as an instructional aids and then play gabat'a game. The group performance is assessed and their mean is compared as well.

Counting and number concept instruction without gabat'a game (CIGO): this lesson delivered in the second experimental group similar in contents with the first one but students don't play gabat'a. At the end, its effect was measured by achievement test.

Arithmetic instruction without gabat'a game (AIGO): this lesson delivered in the second experimental group similar in contents with the first one but students don't play gabat'a. At the end, its effectiveness was measured by achievement test.

1.10. Organization of Dissertation

This dissertation entails five chapters. **Chapter one** introduces the statement of problem, research questions, hypothesis, theoretical and conceptual framework, significant of the study, delimitation, operational definitions and organization of dissertation. **Chapter two** provides a literature-based background for the study by presenting an overview of definitions; identification, assessment and intervention of children with MD, instructional approaches for students with MD. **Chapter three** presents method of the study which includes sampling design, research design, different measures, experimental procedure, treatment, and procedure used for data collection and analysis. **Chapter four** portrays the major findings of the study entailing preliminary analysis, main finding of the effect of CNC, arithmetic instruction, the relation among pertinent variables. **Chapter five** discusses the major findings and its implication; and synthesizes conclusion of the major outcomes and indicates the future directions.

Chapter Two
Literature Review

2.1.Introduction

In this literature review, the combinations of predominant empirical studies, and theoretical approaches that focused on mathematics learning for elementary students with learning disabilities that were published in peer-reviewed journals were reviewed. Studies that met the following criteria were included in the review: First, peer reviewed journals from old to current. Second, empirical studies investigating aspects of MD include prevalence of MD, identification, assessment and intervention. These studies are based on experimental, quasi-experimental, single subject, survey and qualitative methods. Third, in order to maintain elementary students in focus, participants were between 7 and 14 years old. Fourth, it needs to include a description of the mathematical tasks, this allowed evaluation of the mathematical domains, strands, and effects.

Hinged on the combination of theoretical and empirical approaches, the review began by getting a bigger picture of the concept and definition of learning disabilities; leading to the very specific one, mathematics difficulties, its definitions, prevalence, causes, characteristics, types and comorbidity are discussed. Having this pertinent information, the core issues of identification, assessment and intervention are explicated in some details below. In particular the effects of instructional intervention enacting game and without game on students with MDs' mathematical achievement and motivation are scrutinized, referring through the most relevant experimental research viz., pretest-posttest-control group and single subject design. The salient instruction approaches are discerned, CRA with explicit and game based instruction. The review explicates that these two approaches play a prominent role for group intervention.

2.2.Mathematics Difficulties and Associated Concepts

2.2.1. Definitions

Before go through the specific definition of MD, it is pretty important getting a bigger picture of learning disabilities by putting a brief definition of it. The definition of learning disability has varied over time, across jurisdictions and among disciplines. So far, having single universally accepted definition of the condition is obscured, despite the fact that the term "learning disabilities" has been in use since 1962 (Hammill et al., 1987). Current descriptions and definitions of learning disabilities are found in the World Health Organization's disabilities, U. S. Department of Education (IDEA), Learning Disabilities Associations and the National Joint Committee on Learning Disabilities and some others have contributed their own part in the definitions. In spite of the fact that, the definitions are variant and vague in language readily to be understood and applied by those who have learning disabilities, their families and those who work in the relevant helping profession; they contain some common features. The lack of consistent definition represents a major barrier for people with learning disabilities. To deal with this and other related issues, a new definition of learning disabilities from Learning Disabilities Association of Ontario (LDAO) is developed. "Learning Disabilities" refers to a variety of disorders that affect the acquisition, retention, understanding, organization or use of verbal and/or non-verbal information (Stephenson, 2002). The definition demonstrates that the problem is related to one or more psychological processes of learning, in tandem with otherwise average abilities essential for thinking and reasoning. Learning disabilities are specific not global impairments and as such are distinct from intellectual disabilities. Learning disabilities range in severity and invariably interfere with the acquisition and use of one or more of the following important skills:

- oral language (e.g., listening, speaking, understanding)
- reading (e.g., decoding, comprehension)
- written language (e.g., spelling, written expression)
- mathematics (e.g., computation, problem solving)

Besides, it is defined in a more detailed and comprehensive way by IDEA 2004 (U. S. Department of Education, 2004) as:

> A disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. Specific learning disability does not include learning problems that are primarily the result of visual, hearing, or motor disabilities, of mental

> retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage (34 CFR § 300.8(c)(10]).

This definition is unchanged from those found in previous versions of federal law, such as IDEA 1997, and unchanged from the definition in the 1999 state guidelines.

Hinged on these definitions, it is possible to point out that mathematics difficulty is a disorder of one psychological process of learning disabilities, which needs further elaboration for this study.

What is a Mathematics Difficulty?

A range of mathematical instruction research literature utilizes the term *MD* to allude to students having a math disability, who are currently identified, and those at risk for math disabilities (Gersten et al., 2005; Fuchs et al., 2010). It has another name "Dyscalculia" is a contemporary derivative of the Latin "dys", which means a form of special difficulties – not inabilities! - and the Greek "calculus", freely interpreted this word means “counting-stone”. Out of this combination, “dyscalculia” was created, to refer to difficulties with counting. So, this name is used interchangeable with MD throughout this study. The concept of developmental dyscalculia appears to have been introduced in the 1960s and 1970s (Kosc, 1974), though there was some earlier awareness about it. Dyscalculia was formally recognized as a specific learning disability by the DfES in 2001(Department for Education and Skills, 2001). It was defined as:

> A condition affects the ability to acquire arithmetical skills. Dyscalculic learners may have difficulty understanding simple number concept, lack an intuitive grasp of numbers, and have problems learning number facts and procedures. Even if they produce a correct answer, or use a correct method, they may do so mechanically and without confidence (p. 2).

MD has been considered as a ‘Specific Disorder of Arithmetical Skills’. This specificity of impairment is not explainable in terms of on the general intellectual disabilities or of inadequate schooling. World Health Organization (2010) indicates that the specific disorder concerns mastery of basic computational skills of addition, subtraction, multiplication and division, but not on the more abstract mathematical skills involved in trigonometry, algebra, geometry or calculus. Sharma (2003) highlighted that there can be both quantitative and qualitative of dyscalculia, a trouble in counting and calculating can be quantitative; whereas a struggling with conceptualizing and integrating quantitative processes and spatial sense; or mixed, which can be associated with qualitative. Muter (2013) commented that spatial and perceptual difficulties can impact on the child's ability to understand visual concepts in math, e.g. geometry and symmetry, fractions.

In short, the definitions are workable to use in Ethiopian context taking a look at the specific items of BANUCA and other relevant materials can be generalized to those definitions. Particularly, Gersten et al. (2005) designed the defininition of students with MD as those students "performing in the low average range (e.g., at or below the 35th percentile) as well as those performing well below average" (p. 294). A multitude number of students, who exhibited difficulties with mathematics, may come from economically and educationally disadvantaged backgrounds (Aud et al., 2011). For these students, their MD manifest early and remain persistent throughout the later grades. Typically, Klein et al. (2008) and Starkey et al. (2004) indicated that they joined school and get small amount of informal experiences in early mathematics, including counting and use of math vocabulary. This leads them at an elevated risk for math failure. Researches show that such problems occur owning to poor instruction and a variety of cognitive correlates, including processing speed, working memory, and attention (Fuchs et al., 2005; Gersten et al., 2005).

2.2.2. Prevalence

Sue Gifford says that although findings of prevalence studies on dyscalculia ranged between 3 and 6 %, other researchers concluded that a realistic estimate was 5%, as with dyslexia (Gifford, 2005). Researchers have found it difficult to establish how many people suffer from dyscalculia because different criteria are used for identification. Despite that it is estimated that up to 6% of the school-age population have severe specific difficulties (Butterworth, 2005; Talepasand & Hanifi Vahed, 2012).Additionally, 5% to 10% of school-age children exhibit mathematics disabilities as found out by the researchers (Fuchs et al., 2005; Fuchs et al., 2007b).The growing body of research on young children's mathematics cognition has greatly contributed to our understanding of the early numeracy skills that prove problematic for students at risk for mathematics disabilities. The figures are global, these numbers may increase pondering Africa, but it has not yet known in Ethiopia, so far. Multitude numbers of students exhibit enormous challenges and difficulties in learning mathematics (Dowker, 2005; Jordan et al., 2003).

2.2.3. Causes

At present, there is very little agreement about what causes dyscalculia. However, neuro-physiological experimental studies indicate that it is caused by the way the brain is structured (Dehaene, 2001). Significant MD may also be caused by other coexisting conditions**,** such as dyslexia, dyspraxia, & attention deficit hyperactivity disorder. Math anxiety can result from having MD & exacerbate MD

2.2.4. Characteristics

Dyscalculia has the following characteristics:

- **Arithmetic:** The most consistently observed behavioral hallmark of dyscalculia is impaired arithmetic fact retrieval (Mazzocco et al., 2008). Butterworth (2004) indicated that children with MD typically fail to develop fact-retrieval mechanisms, and typically developing peers have progressed to memory-based strategies, while atypical developing children continue to employ procedural strategies.
- **Basic Number Processing: I**n the experimental study on number magnitude (Koontz ,1996) and distance effect (Moyer &Landauer, 1967) reported that atypically developing children exhibit difficulties judging whether two numbers presented in different formats are identical or not ; and as the distance between two numbers being compared decreases (e.g., 2 – 9 versus 7 – 9), reaction times and errors increase.
- **Non-numerical Deficits:** Learning disorder *specific* to arithmetic is the generally accepted definition of Dyscalculia. Passolunghi and Siegel (2004) informed that different experimental studies on cognitive neuroscience suggest that the origin of the cause may lie in disturbances of domain-general cognitive mechanisms (working memory, or attention.).
- **Neural Characteristics:** Experiments on neural mechanisms of math skill, then most deficits would be in the neural substrates of numerical processing (Dehaene, 2001).

2.2.5. Types

There are many different types and subtypes of dyscalculia (Karagiannakis et al., 2014).Here are some of them:

- **Developmental dyscalculia:** Children find difficult to count, recognize mathematical signs, calculate and confuse with numbers.
- **Acalculia:** Student is unable to carry out normal mathematics like calculation.
- **Verbal dyscalculia:** Children find difficult to name verbally, name the symbols, signs and counting of numbers and items.
- **Operational dyscalculia:** It is associated with difficulty in applying rules during mathematical operations. It also leads to confusion in identifying mathematical symbols.
- **Sequential dyscalculia:** This disorder refers to disability to count numbers according to sequence also problem with calculating time, checking schedule, tracking direction, etc.

2.2.6. Comorbidity

Although, there is a high rate of co-occurrence between MD and reading difficulties, specific MD with normal development in other cognitive and academic areas are well documented (Jordan et al., 2007; Butterworth & Reigosa, 2007). It can occur with dyspraxia (Yeo, 2003), and these might be accompanied by weaknesses in attention and math anxiety (Chinn, 2012).Besides, a central correlation of MD is reading disability. Estimating about 40% of children with dyslexia also exhibit maths disability (Lewis et al., 1994). It is based on whether or not children with MD have a comorbid reading disability, subtyping dyscalculic children can be done. Hanich et al. (2001) stress that comparing MD with MDRD, children with MD-only exhibit higher perfomane than to children with MDRD. This is because mathematical concepts may be mediated by language but not in ones that rely on numerical magnitudes, visuospatial processing, and automaticity.

2.3.Mathematical Development: Comparing Children with MD and without MD

2.3.1. Counting Knowledge

Based on the study ofGeary et al. (1992), the performance of first-grade children with MD were contrasted with their normally achieving peers for tasks that assessed all of Gelman and Gallistel's (1978) basic principles and most of Briars and Siegler's (1984) unessential features of counting. The pattern of the studies suggests that many children with MD in second grade exhibit difficulties to wholly understand counting concepts, and many first graders with MD during assessing the counting process show up challenges holding information in working memory (Hoard et al., 1999).

2.3.2. Arithmetic Development

For typical development, for solving simple addition problems (e.g., 4 + 2) in their first learning, children initially count both addends. To do this, Berteletti and Booth (2016) explicate that they enact counting procedures utilizing the finger counting strategy, and sometimes verbal counting strategy without the aid of finger, The min counting on and sum (or counting all) are the two most commonly utilized counting procedures, whether children use their fingers or not (Fuson, 2020). As indicated by Geary, et al. (2004), at the time of formal schooling, children utilize vertical and horizontal addition strategy for solving complex problems, such as 27 + 38. This is done through summing the ones-column integers and then summing the tens-column integers.

Putting children with MD into consideration, in comparison with typical developing peers, children with MD use the same types of strategies (e.g., verbal counting)during the solving of simple arithmetic problems (e.g., 4 + 3), but differ in the strategy mix, strategy accuracy, and in the pattern of developmental change (Hanich et al., 2001; Jordan & Hanich, 2000). For first and second , Geary and colleagues (Geary et al., 2000) found that children with MD committed more counting errors and used the developmentally immature sum procedure more frequently than did their normally achieving peers or children with reading disability. Besides, the most consistent finding in this literature is that children with MD have difficulty retrieving basic arithmetic facts from long-term memory (Ostad, 2000). They, in contrast with children with typical development, did not show shift from heavy reliance on finger counting to verbal counting and retrieval, but instead relied heavily on finger counting in both grades, and continued to commit finger and verbal counting errors. Geary et al. (2004) indicated that in comparison with typically achieving peers in fourth grade, children with MD performed more execution and working memory errors utilizing the same types of counting and decomposition strategies.

Pondering the number combination study, any students who struggle with mathematics demonstrate a lack of skill with number combinations (Andersson, 2008; Hanich et al., 2001). According to Anderson (2008) the third- and fourth-grade students with MD performed significantly lower and made more errors on a test of number combinations than students without MD. Geary et al. (2004) stress that these problems emanated from difficulties in storing and retrieving number combinations from long-term memory or from deficits in keeping number combinations in working memory.

2.3.3. Working Memory and Counting Span

Working memory is the ability to maintain explicitly a mental representation of some amount of information, while being engaged simultaneously in other mental processes. According to Baddeley (2000) working memory is dependent on a central executive that is expressed as attention-driven control of information represented in three slave systems, a language-related phonetic system, a visuo-spatial sketch pad, and an episodic buffer. Debates regarding the nature of these components of working memory are discussed elsewhere (Baddeley, 2012). The issues here concern developmental change in the overall capacity of working memory in normally achieving children, and the working memory of same-age children with MD.

For typical developing children, the capacity of the development of working memory increases from preschool through the elementary school years. As an example, preschool children can hold three to four items of some forms of information, such as numbers, in working memory, whereas a typical fourth grader can hold five to six items (Kail, 1990). The mechanisms underlying these developmental changes appear to include an improved ability to use strategies, such as rehearsal, to keep the information active in working memory (Kreutzer et al., 1975), and changes in more fundamental components that support age-related improvements in working memory capacity. The latter include one or some combination of an improved ability to control the focus of attention, increased speed of processing information represented in the slave systems, or slower decay of information represented in the slave systems (Cowan et al., 2002).

Children with MD do not perform as well as their same-age peers on a variety of working memory tasks (Geary et al., 1999). One often-used task, counting span, is highly relevant in terms of the working memory processes involved in the use of counting procedures (Conway, 2005). Geary (2004) conjectured that children with MD commit more counting errors as a result of poor working memory resources and highly depend on finger counting. If so, then measures of working memory, such as counting span, should be related to individual differences in use of finger counting and frequency of finger and verbal counting errors, and should contribute to differences in these strategy variables comparing children with MD to their counter parts.

2.4.Mathematics Difficulties: Identification

Because of the additional costs involved in educating children with MD, as well as the potential stigma associated with a disability label; accurate identification is crucial. Through a variety of ways, mathematics disabilities can be identified. Over a period of time, the teacher and/ or parents can figure out whether a child's difficulty in learning mathematics persistent or not by making observation and working directly with a child (Bryant, 2009). Information about the child's performance can be gathered in several ways. Weekly tests, homework, and class work samples are examples of information the teacher can collect about the child's progress learning the mathematics curriculum. There are a variety of formal assessments that can be used to identify math skills and concepts that are problematic for the child. The following are examples of some of the more common assessment measures (Bryant, 2009):

- **Curriculum-based assessments** relate specifically to the skills and concepts typically taught in a certain grade level.
- **Diagnostic assessments** provide information about a student's strengths and weaknesses compared to students of the same age or grade level.
- **Achievement assessments** broadly measure areas of academic knowledge and application and compare a child's performance to that of students of the same age or grade level.

For the current study, identification is a bench mark of starting this dissertation work, implicitly the aforementioned assessment measures were taken for this study, such as BANUCA as a diagnostic, and achievement test for pretest and post test as an achievement assessment.

2.4.1. Different Models for Identifying Learning Disabilities

There are three specific learning disabilities (SLD) identification methods, Discrepancy Process model, the Response to Intervention (RtI) model and/or the Alternative Research Practice. In the discrepancy model, the school psychologist determines if there is a significant discrepancy between a child's potential (intelligence) and achievement. It is viewed by many as an inappropriate method for identifying SLD, in part because a child must experience academic failure before her/his LD is identified. With this in mind, the current Individuals with Disabilities Education Act (U. S. Department of Education, 2004) legislation permit school districts to use alternative procedures for identifying LD. The response-to intervention model looks at how a child responds to research-based instruction over time (Fuchs & Fuchs, 2001). In this approach, math instruction that is delivered in small groups and tailored for the child's learning needs is implemented and the child's progress noted. In third approach, student performance is evaluated with the goal of identifying strengths and weaknesses in the areas consistent with the definition of SLD. For a student to be eligible, the data on the student's performance should indicate those specific academic and basic psychological process deficits included in the IDEA's definition of SLD. IDEA lists eight specific areas of academic deficiency (34CFR 300.309). This approach is based on the concept of "unexpected underachievement."

2.5.Mathematics Difficulties: Assessment

It is possible to conduct a math assessment using various measures and procedures. It is elaborated as follows;

2.5.1. The Dyscalculia Screener

The *Dyscalculia Screener* (Butterworth, 2004) is very useful for screening a population of pupils aged 6 to 14 in order to select those who should be put forward for further investigation of their mathematical development. It is their experience (Emerson & Babtie, 2014) that the primary deficit in dyscalculia can be taken to be poor number sense that affects the acquisition of the four basic operations – addition, subtraction, multiplication and division – and the application of these operations to solving word problems. Further investigation can be conducted informally using *The Dyscalculia Assessment* (Emerson & Babtie, 2014) to find out if the pupil shows evidence of number sense and any ability to calculate, rather than counting in ones to solve number problems. Number sense consists of having a 'feel' for numbers which involves understanding that a number represents a specific value which is part of a sequence and can be compared with other numbers in terms of magnitude. Early number sense could be demonstrated by the use of counting to solve 'one more' and 'one less' problems.Despite having several test batteries, the most common standardized tests are:

- **Wechsler Intelligence Scale for Children**: In the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003) is most commonly used. The information obtained gives four Index Scores which provide a summary of the pupil's verbal and non-verbal abilities as well as information concerning working memory status and speed of processing. With this information, the practitioner can assess the strengths and weaknesses of an individual learner and the impact these can have on their math learning.

- **Comprehensive Test of Phonological Processing**: This could indicate a dyslexic profile. Why is the differential diagnosis of these conditions important? It is important because both dyslexia and dyspraxia can affect the development of mathematical skills.

The Dyscalculia Assessment (Emerson & Babtie, 2014) can be used to conduct a formative assessment of pupils in order to provide evidence on which to plan teaching.

2.5.2. Sections of Dyscalculia Assessment

The areas of dyscalculia assessment are described as follows:

- **Number sense:** It can be assessed by investigating students' ability to estimate quantities and subtilize small numbers of items without counting. As per Hudson and Miller (2006), number sense refers to a child's fluidity with and awareness of numbers. The apparent possessing of number sense permits one to achieve everything from understanding the meaning of numbers to developing strategies for solving complex math problems (Berch, 2005). Difficulties with number sense typically cut across the conceptual and procedural aspects of math.
- **Counting and the number system:** The ability to count forwards and backwards from roughly age-appropriate points in the counting sequence can be investigated to assess flexibility of counting. Awareness of number relationships can be looked at through the use of comparative vocabulary of 'more than' and 'less than'.
- **Calculation:** The four numerical operations are investigated to check conceptual understanding. Many pupils with mathematical weaknesses may know that 3 x 2 = 6 but are unable to explain in words or with objects that the equation means 3 groups of 2 and how that differs from 2 x 3 even though the answer 6 is the same in both cases.
- **Place value:** Pupils' knowledge of place value can be checked to find out if they can write numbers involving units, tens and hundreds of thousands as well as those containing zeros.
- **Word problems:** Word problem solving should also be assessed to check if pupils are able to apply their knowledge and understanding to realistic situations involving number.

This dissertation focuses on counting, addition and subtraction. So, some detail explanation is done as follows

2.5.3. Assessment: Counting

There are two types of counting. Based on this,

Procedural Counting. As explicated by Martin (2011), it is assessed with *Oral Counting* and *Counting Down*. Students count aloud from "1" for one minute. Scoring was done by counting the number of correctly identified digits minus the number of errors was recorded, and converted to a numbers-per-second metric. Counting Down requires children to count down from 10, and then from 20, as quickly but as accurately as possible.

Conceptual Counting. Martin et al. (2014) explained that the assessment of conceptual counting is done through *Count Out Objects* and *Puppet Counting*. For the 5 items of the Count Out Objects measure, children see pictures of boxes and cars (5 boxes and 4 cars; 6 boxes and 7 cars; 8 boxes and 7 cars; 7 boxes and 7 cars; and 4 boxes and 4 cars) randomly displayed on a page, and are instructed to "Count out loud, ALL of the things on this page." Thereafter, without delay, the child was requested to answer, "How many are there altogether?"

- **Abstraction** (only one type of object (e.g., cars) was counted),
- **One-to-one correspondence** (double counting an item),
- **Stable order** (disruption of the counting order), and
- **Cardinality** (mismatch between the final number counted and the response to the "how many" question).

2.5.4. Assessment: Addition/Subtraction

According to EGMA of Reubens (2009), the assessment of calculation is based on knowledge of the key number bonds: bonds of ten, doubles and near doubles.

Early calculation: addition +1, +2 and subtraction –1, –2. The child should give fluent rapid answers to adding or subtracting one or two by making the child to count one or two forwards or backwards.

Doubles and near doubles. The doubles facts up to 10 + 10 should be known 'off by heart'. Children should also be able to explain the relationship between doubles and near doubles, showing they understand that if 2 + 2 = 4 then 2 + 3 must equal one more than 4. If they do not understand this it indicates that they have weak reasoning ability about numbers. There is a need to enact the doubles facts to higher values through the decades up to 100 and beyond (Example: If 3 + 3 = 6, the child should be able to reason that 30 + 30 = 60. They should also be able to work out that 13 + 3 = 16 and 53 + 3 = 56 by applying the same fact. The mantra ‘same fact different value’ can be useful.)

Note if the child is using a strategy, such as:

- ✓ deriving an answer from a known fact, e.g. 5 + 5 is 10 therefore 6 + 6 is two more than ten
- ✓ using a calculation strategy such as bridging, e.g. 6 + 7 = (6 + 4) + 3 = 10 + 3 = 13.

2.5.5. Procedure of Conducting Assessment

According to Emerson and Babtie (2014), the following steps are the procedure of conducting assessment of dyscalculia

- Start with an empty table.
- Get the child to relax.
- Encourage the child to talk about what they are doing and thinking.
- Give the child enough time to answer.
- Stop after two or three errors in each section and then move to the next section.
- Observe levels of anxiety throughout. Take a break if the child is very anxious.
- If the child really struggles with early sections, do not proceed to the end of the investigation.
- Give non-specific praise in the form of encouraging comments. Do not give feedback about right or wrong responses.
- Record information and write up as soon as possible after the assessment.

In conclusion, the assessing instruments that were mentioned before are relevant for this dissertation, but some of them are not. For example, the dyscalculia screener is compatible with BANUCA in terms of contents, time allocation, etc. But, the former one is computer based whereas BANUCA is paper based. Wechsler Intelligence Scale for Children, and Comprehensive Test of Phonological Processing could not be applicable at this point in time.

2.6.Mathematics Difficulties: Early Intervention

Investing in early intervention (EI) yields tangible returns, especially for children with special needs. Early childhood is the time when the brain develops most rapidly and it is a critical window of opportunity for establishing the overall development of a child's cognitive, physical, psychosocial, immunity and other health outcomes. Putting this in mind, similarly, there is evidence that early intervention can prevent significant difficulties for many learners (Berch & Mazzocco, 2007; Gersten et al., 2005), including learner with MD and competence in mathematics depends heavily on appropriate and effective intervention, and on opportunities to learn. To do so, different principles of intervention specific to MD are explicated as follows,

2.6.1. Principles of Intervention Specific to Mathematical Difficulties

Dowker (2004) set out some general principles for intervention for children with MD. These are;

- interventions can take place at any time in a child's school career, but ideally should take place relatively early, both because MD can affect performance in other areas of the curriculum, and in order to reduce the risk of children developing negative attitudes and anxiety about mathematics.
- interventions that focus on the specific components with which a particular child has difficulty are likely to be more effective than 'one size fits all' programmes.
- within mathematics intervention scheme, assessing children's specific strengths and weaknesses is pretty important to target each individual child's weaknesses.

2.6.2. Effect of Early Numerical Intervention on Mathematics Achievement and Motivation

Jordan et al. (2009) indicated that the levels of mathematics achievement can be predicted by the early number competencies and it predicts the occurrence of MD (Mazzocco & Thompson, 2005). Understanding of number concepts and relations helps children perform arithmetic operations and can be applied to other mathematical domains such as measurement, data analysis, and geometry (Cross et al., 2009). Robinson et al. (2002) specify that children having poor number competencies and highly depend on rote memorization, which turns out to be weak problem-solving skills. Various types of intervention strategies play a paramount role for enhancing students' with MD mathematics achievement and improving their motivation.

Clarification on the effect of instructional intervention on achievement, comparing related theories, correlation of achievement with other factors and definition are expounded as well. To begin, various researches have been done on the effect of instructional intervention within the field of mathematics disabilities. So researchers figured out numerous interventions and approaches so as to support students with MD and other learning disabilities, viz., explicit instruction (Gersten et al., 2009), game based instruction (Wan Ahmad et al., 2010), computer-assisted instruction (Seo & Woo, 2010), mnemonic strategy instruction (Manalo et al., 2000), schema-based instruction (Jitendra et al., 2002), cognitive strategy instruction (Montague & Dietz, 2009), representations (Jitendra et al., 2016), and the CRA instructional framework (Kim, 2020; Hinton & Flores, 2019). For this dissertation purpose, only few of them got attention.

The Concrete–Representational–Abstract (CRA) Instructional Framework and Its Effect. This option of instruction was chosen as instructional method for the present study. The instructional framework is a graduated instructional sequence and plays a crucial to teach students in mathematics (Agrawal & Morin, 2016); specifically, the CRA sequence is valuable to carry out teaching mathematics interventions for students with MD. According to Flores (2010) the CRA instructional framework is enormously important to maintain a focus to get understanding on concepts, to make the participation of teachers, to support students in a concete fading instruction, and to utilize multiple lessons for student mastery of mathematical procedures. CRA is implemented using three explicitly taught representations in which students work using numerical symbols with the visual support and hands-on models for teaching students the conceptual meaning of numbers and operations (Miller et al., 2011).

First, instruction includes concrete objects. The teacher models the concept using objects to solve problems. For example, the operation addition means to combine; modeling the operation involves showing students that the symbols within an equation mean that two amounts of physical objects are joined together to form another amount. After lessons with concrete objects, instruction moves to the representational phase. In the representational phase, handwritten lines or dots; pictures and drawings convey the meaning of mathematical symbols within tasks or equations. The phase is also referred to as semi-concrete. The abstract phase is the last phase of CRA instruction in which there are no visual supports and mathematical tasks are completed using just numbers. Once students master solving problems with numbers only, the instructional focus is building automaticity and accuracy.

Fyfe et al (2015) or Flores (2010) renders evidence on CRA how concrete and pictorial representations support students to improve mathematical concepts better; however, an apparent direction on how to make the connections between phases had not been provided. Kim (2020) suggested, very recently, the framework of concrete fading of instructional strategies in connecting the stages between phases. The instructional strategies for the connecting stage between the enactive and iconic phases are expounded as follows:

- Teachers help in the provision of graphical representation from concrete objectives with manipulative in mathematically meaningful ways.
- By focusing on related and essential elements of physical activities by ruling out the irrelevant, it is possible to make students gradually step into making linkage between physical activities and pictorial forms. At the time of entering iconic/pictorial phase, teachers can render support for students by utilizing visual representations on the core mathematical concepts. Teachers role on the connection between the iconic/pictorial phase and the symbolic/abstract phase are to
  - Give a brief introduction of the abstract form of mathematical concepts;
  - Give support to children to interpret activities with visual representations in mathematically meaningful ways; and
  - Rule out irrelevant and unassociated elements from activities with visual representations to emphasize the core structures of concepts.

Taking these strategies into consideration, teachers can help students focus on the core structures of mathematical concepts, which is a stepping-stone to the symbolic phase of concept development. Teachers play a role to help students making linkages between pictorial and symbolic representations, and even further linkage with concrete activities when students eventually get into the symbolic/abstract phase. This is indeed helpful for students for understanding abstract concepts through interpreting unambiguous objects (Son et al., 2012).

Utilizing the CRA instructional framework with explicit instruction is a recommended mathematics pedagogical approach for students with disabilities (Gersten et al., 2009; Powell, 2015). Explicit instruction entails a sequence that starts from teachers guiding (i.e., cuing or prompting) children through the various procedure of a mathematics problem to finally switching strategies students to solve problems independently (The National Mathematics Advisory Panel, 2008). Within the CRA instructional framework, each lesson involves explicit instruction

(Doabler & Fien, 2013). In the previous literature, Agrawal and Morin (2016) referred to the CRA instructional framework in mathematics as an evidence-based practice, given the quantity of research published on this practice. Likewise, given it was highly researched, Powell (2015) indicated that in the area of mathematics the CRA instructional framework is considered as an evidence-based practice. With multiple individual studies assessing this strategy and demonstrating its success for teaching mathematics to students with disabilities, this evidence-based synthesis seeks to support and confirm the CRA instructional framework as an evidence-based practice through the application of Cook et al.'s (2014) standards and quality indicators of an evidence-based practice.

Concerning the contents of CRA, various researches have been done. Early CRA research focused on basic number operations such as addition, subtraction, place value, multiplication, and division (Peterson et al, 1988; Mercer and Miller 1992). Peterson et al. used explicitly taught place value skills to students with disabilities in elementary and middle schools who received instruction in self-contained special education settings. Within small-group settings, teachers used CRA to teach basic addition and division skills (Mercer and Miller 1992). Harris et al. (1995) taught single-digit multiplication to students with disabilities in the general education classroom. CRA research expanded to include skills such as regrouping, integers, and fractions and included students with disabilities (Flores et al., 2014; Flores, 2010; Kaffar & Miller, 2011; Watt and Therrien, 2016).

With respect to the effect of CRA, Hinton and Flores (2019) investigated the effects of CRA on the performance of elementary students across varied areas of need via a multiple baseline across behaviors design for two students who were at risk for mathematics failure. The students' needs were associated with poor conceptual understanding of numbers and operations. The students improved their performance across each of the mathematical concepts taught using the CRA sequence. This is consistent with previous CRA research (Flores et al., 2014; Kaffar & Miller, 2011) in which instruction using the CRA sequence improved students' abilities to solve operations that involve subtraction with regrouping and fractions. Additionally, students also exhibited improvement in rounding and fraction comparison. Findings on students' improvement in fraction comparison research , Watt and Therrien's (2016) reflect that students improved in fraction knowledge. For example, students had difficulty with rounding, solving subtraction with regrouping, and comparing fractions which all required tailored supplemental instruction using

CRA to address poorly formed concepts of numbers. Prior to the study, student error patterns demonstrated novice mathematical conceptions of numbers that interfered with their performance across skills such as rounding, regrouping, and fraction concepts. Students must build a fluid understanding of the magnitude of numbers if they are to perform mathematical tasks that include conceptualizing how numbers can be represented in several ways, or compare numbers while performing mathematical tasks (Gersten et al., 2005; Van De Walle, 2004). It is important that researchers explore methods teachers may use to shape effective interventions that address a variety of skills tailored to diverse student needs. With respect to the effect on mathematics motivation, the study of Ibrahim (2017) demonstrated that there was the effect of CRA approach on children' motivation but no effect of CRA on retention of motivation in learning fractions.

Game Based Instruction and Their Effects. Few scientific studies report experimental data confirming the possible link between achievement and the ability to solve mind games, despite the fact that research studies in the field have evidenced that the use of games can:

- Offer a variety of educational benefits (Hong et al., 2009);
- Promote the development of cognitive and complex problem solving skills (Felicia, 2009);
- Contribute to the enhancement of school performance (Franco et al., 2011).

The research study refers to confirm such results and shows that there is a strong correlation between school achievement and the ability to play and solve mind games and that, however, motivation and engagement in game-based learning tasks is very high, heedless of the level of achievement of the students involved.

According to Worth (1981), a mathematical game is a kind of game that utilize a type of play that follows a collection of rules, targets at definite goal or outcome, and entails competition against other players. A game is regarded as a mathematical when the players can perceive and/or influence the course of the game on the basis of mathematical considerations (Rudiger, 1994). Mathematical games may be used to introduce concepts as a prelude to explicit teaching or practice skills or consolidate a concept after explicit teaching. Educational games do lead to improved learning (Dennis & Stewart, 1999). Some researchers have evaluated the effectiveness of mathematical games and gave reasons for the use of games. Among them are the powerful motivation, involvement, and the development of positive attitudes in learning have long been recognized as being essential and necessary. Games are also valuable for encouraging social skill, for stimulating discussions, helping the development of understanding, for developing strategies for learning new concepts, reinforcing skills and concepts as an aid to symbolization and logic (Oldfield, 1991).

Multiple researches have been done about game based learning on mathematics achievement and motivation, but most of them are focused on students with typical developing than atypical. Previous research atypical children (Sideridis & Tsorbatzoudis, 2003) has found that children with learning difficulties are on average, more avoidance oriented and generally lack motivation in learning, compared to their typically developing peers. Therefore, future research might investigate whether using game-like activities as part of the intervention programme provides means for increasing the motivation of low-performing children in their mathematics learning. Prensky (2001) referred that for teaching challenging concepts and complex procedures, instructional games are considered to be effective tools, because they

a. use action instead of explanation,
b. create personal motivation and satisfaction,
c. accommodate multiple learning styles and skills,
d. reinforce mastery skills, and
e. provide interactive and decision making context (Charles & McAlister, 2004)

Given these benefits, an increasing number of educators need to use instructional games in formal school settings. Hence there are various types of game that plays a prominent role for influencing the mathematics achievement and motivation of students with MD.

Instruction via board games and their effect. What is board game? Board games are an important tool to provide hands-on and heads-on skill and knowledge development for people of all ages on all subjects. Not only do well-designed games create an engaging atmosphere, they also provide a nonthreatening, playful, yet competitive environment in which to focus on content and reinforce and apply learning. Different board games have been made various times for the purposes of instruction and for game itself. These games were designed culturally (Alex de Voogt et al., 2018), and based on theories and empirical research regarding the mental number line (Ansari, 2008).

Cultural board games. The traditional math board game whose existence has been documented as early as 1500 B.c. and is found in varied forms throughout Africa and Asia

(Natsoulas,1995).Within the rules of the game, however, there may be found a sense of unity as well as a reflection of the diversity of the many peoples who play it. In the multiple lap games played in Africa, capture of counters, capture of houses, and end of turn are the rules that extrapolates the common elements of board format. Common elements are found among geographically diverse peoples, but there are distinct variations among neighbors; in English it is called Mancala, in Ethiopia it is called gabat'a , in Ghana it is called oware, in East Africa it is called sora, and in Nigeria it is called ayo.

Its cultural diversity is reflected in the varied rules by which it is governed which also allow the game to be played at differing degrees of complexity according to the skills of the players. Ascher and Ascher (1994) asserted that each culture possesses its own sets of mathematical games. They stressed that mathematical ideas are panhuman and are developed within cultures. Mathematical ideas are taken to be those that involve numbers, logic, spatial configuration and most importantly, the combination or organization of these into systems or structures. From culture to culture and within any culture, mathematical games and ideas appear in various contexts. Specifically, Ethiopia is one of the few countries, having its own Amharic alphabet and different cultural mathematical words and games. There are several varieties played in Ethiopia. *Gabat'a,* Bell and Cornelius (1988), was the most prominent game that was being played in Ethiopia in different cultures, having its own rules. According to Natsoulas (1995), the game was first introduced to the author by Ethiopian acquaintances in Addis Ababa. As originally described, the game was a blending of basic elements common to many versions. It is possible to conceptualize a unity in the diverse rules of play by extracting a set of universais and describing the differences as variations on such basic themes. Focusing on the game in the African continent, the common elements of Mancala and the ethnography of the variations will be described below. This will be followed by a discussion of opening moves and strategies and the simulation of a typical game.

The participants of the game are two persons for the Mancala game (Natsoulas, 1995). The structure of mancala as a board, having rows of holes or "houses," that is two rows of six holes each with two large holes at either end (see Figure 3). The board is placed between the two players and each player owns the houses on his/her side. Seeds, beans, pebbles, or beads are placed in the houses and moves are in a counter clockwise rotation around the board; the banks are used only to store captured balls. At the start of playing the mancala game, the arrangement of the board game are explicated as follows;

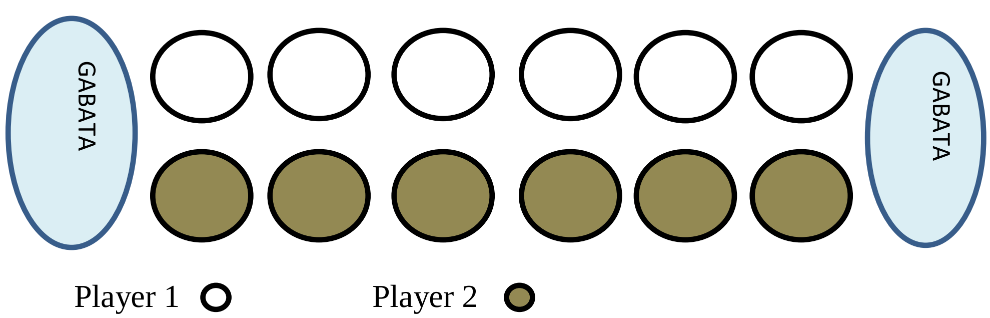
Firstly, the number of balls is placed in each house, mostlty four, and each player owns all the counters on his/her side of the board.

Secondly, two players start the game and their ultimate goal is to make one's opponent player incapable of continuing play by capturing his/her counters. This is done by capturing counters directly for storage in his/her bank or there is also some variations that through the acquisition of the opponent's houses. The variations differ from culture to culture, three universal aspects lead to variation including board format, rules of capture, and end of a player's turn.

Finally, a round of the game is over during the time that the player is incapable to make a move, despite still having in possession of seeds. Then, a new round may be resumed.

Figure 3

Determining the ownership of the holes and stores



i. Board Format

The board format has three major elements. These are:

a) the number of houses in each row, and vice versa. Most of the time, two rows of houses, each row having 6, 8, or 10 houses are known. Sometimes, boards composed of three rows of houses are known.

b) the number of seeds placed in each hole. At the start of playing game, the number of counters placed in each house may be 2, 3, or 4.

c) a bigger house storage (banks) of captured seeds. It is always the part of the boards.

ii. Rules of Capture

It is the enormous aspect of the game**,** capturing of counters or balls. There is direct and indirect capturing of counters. Directly, the balls may be captured and ruled out of play and put into the storage; or indirectly freezing the contents (counters) by capturing of a house for the remainder of the round.

iii. Direct Capture of Counters

Directly, the counterpart's balls may be controlled and put into storage in a player's bank. This can be done in a number of different ways, which are described below.

a) The time at which a player puts the final seed in hand into one of his/her vacant houses opposite a counterpart house containing any number of balls are captured... This capturing method is the most used.

b) The time at which a player puts the final seed in hand into one of his/her houses opposite a counterpart house containing two balls are captured. The two balls on the opponent side are is captured.

c) The capture of groups of four (or occasionally three balls) occurs when such groups are formed. If the group is formed by a player dropping the last ball in hand into an opponent's house, then the balls are captured by the player; otherwise, they are captured by the owner of the house.

d) The time at which a player puts the final seed in hand into a house preceding an empty vacant house, and the counters, if any, of the following hole are captured on either side of the board. This capturing method is rare. It is seen in Ethiopia (Adigrat and Harar) and Somalia...

iv. Capture of Houses

The other ways of capturing the counters are the capture of an opponent's house. The capture house is out of play for the remainder of the game. Then it belongs to the property of the player who put the house into control. There are three diverse methods of capture of a house permanently.

a. The most dominant ways of capturing the houses occur when the player makes four counters by putting the final seed in the counterparts' houses having three seeds. Besides, it occurs when a player makes three in an opponent's house containing two seeds.
b. Less popularly, the permanent capture of a counterpart's house may occur when a player puts the final seed in hand into one of his/her vacant houses opposite a counterpart's house containing three balls. In this case, the counterpart's house is captured.
c. Once more, the permanent control of one or more holes may happen a player puts the final two or more seeds in hand into his/her counterpart's houses each containing three balls. This is a rare method. Upon the controlling of an enemy house, a player's turn is ended.

v. End of Player's Turn

In a single-lap game a player's turn ends when he/she has finished dropping all the balls in hand. In Africa, the multiple-lap games are mostly used, which will be described in the following ways.

a. Playing is done in anticlockwise direction
b. It is a continuous process that the counters in the holes are dropped and the final ball in his/her hand is picked up and movement around the board is proceeded.
c. The time at which the final ball in hand is put into a vacant hole or a capture is made, then a player's turn ends.

When the players complete laps around the board, they proceed taking turns. One round of the game ends when one of the two players no longer has counters that can be put into play. This happens when there are no balls in his/her holes that can be taken and/or his/her holes that do have balls that have been eliminated from the game by opponent capture. Each player then takes as his /her own the total number of balls in the bank, any balls in his/her remaining houses, and the balls in the captured houses, if any. These counters are then redistributed among the houses. Thus, a new round playing starts by filling many holes from the collected counters.

Regarding the benefits and effects of the traditional board game, mancala and sungka in other countries and gabat'a in Ethiopia, is purely mathematical and the method of playing follows the orderly processes of science. A research by de La Cruz et al. (2000) demonstrated that teachers found such game to be beneficial to students with math learning disabilities. In accordance with this research demonstrating the positive effects of using concrete experiences before teaching students abstract concepts (the concrete-semi-concrete-abstract sequence) (Mercer & Mercer, 1998), this strategy affords teachers the opportunity to provide a wide range of choices. Specifically, the game was found to improve basic math concepts such as adding, subtracting, counting and estimation. Additionally, it facilitated memory, observation and concentration, and encouraged positive social interaction. To strengthen this, Alex de Voogt et al. (2018) indicated that adapting the board game (mancala), it plays a role for teaching early mathematical concepts, counting, addition and subtraction.

To sum up, this traditional board game had no numbers on the board and students benefited implicitly in mental calculation rather than identifying number letters. The next linear board game has number on the board.

Linear board game. Game-based learning can be enjoyable, motivating, and interesting for students, while also providing immediate feedback and information about numbers from playing the game and from the other players (Papastergiou, 2009). Siegler and Booth (2004) specify that board games that are organized linearly, successively numbered, and same pattern spacescan provide kinesthetic, auditory, visuo-spatial, and temporal cues about numerical magnitudes. Notably for counting and numeral identification, linear number board games also render practical activities at other valuable numerical skills (Ramani & Siegler, 2008). Besides, children's numerical knowledge can be improved through playing linear numerical board games. The study using a randomization technique, students are assigned to play either a linear numerical board game with squares numbered from 1 to 10 or a game that is identical except that the squares varied in color but not number. Then, it is found that children who played the numerical version of the game have shown greater improvements in number line estimation, magnitude comparison, counting, numeral identification, and ability to learn novel arithmetic problems (Ramani & Siegler, 2008; Siegler & Ramani, 2009). These gains have been shown to be stable over a 9-week period.

Playing a board game in a small group activity is important. This is because specific education goals can be achieved by extending their learning during and after playing the game (Durden & Dangel, 2008; Wasik, 2008). Communication among the children can be facilitated by teachers provide feedback to one another (Griffin, 2004). Collaboration with peers has been found to enhance learning under many circumstances (Rittle-Johnson & Star, 2009). However, collaboration with peers can also hinder learning in some circumstances (Fawcett & Garton, 2005).

With respect to effectiveness of linear board game, an experimental study of typical developing students on the effectiveness of engaging students through board games on their academic performance was studied by Viray (2016).The findings from this studyreveal that after the engagement in board games, the academic performance of the experimental group is higher compare with control group. Using t-test, it shows that there is a significant difference between the academic performance of the control and experimental group. It further shows that engaging students through board games has a positive effect on their academic performance. A meta-analysis study was made by Turgut and Dogan Temur (2017) investigated the effect of using games in the process of teaching mathematics, and 31 effect sizes of individual studies was calculated. Accordingly, it can be inferred from those studies that using game in mathematics teaching process generally effects academic achievement positively. This result shows similarity with other literatures. Ku et al. (2014) stated that in comparisons with pencil paper based (traditional) learning processes, game based learning is more efficacious in terms of making students to feel more comfortable and their performances enhance in mathematics courses.

The other research supports the use of math board games for increasing the development of number sense in young children (Whyte & Bull, 2008). Starkey et al. (2004) designed a mathematics intervention for preschool children and the results showed significant improvement in mathematical knowledge for the intervention groups when compared with control groups. The study demonstrates that small-group activities and games that utilize concrete materials and adult support can improve the mathematical understanding of young children. A study by Young-Loveridge (2004) examined the effect of number books and games on numeracy development in 5-year-old children who had been identified as scoring in the bottom two thirds on a numeracy measure. The children in the intervention group made significant progress compared with the control group. Although the difference between the groups diminished over time, benefits to children who participated in the intervention remained significant a year following the intervention. However, because books and games were used in the study, it is not possible to determine the relative effect of each type of material.

In addition, Ramani and Siegler (2008) studied the effectiveness of linear number board games for improving the numerical knowledge. In contrast to the previous research discussed, this study isolated a particular type of math board game. Children who played the number board game showed increased proficiency in numerical magnitude comparison, number line estimation, counting, and numerical identification. Although this study includes important information for educators, it does not include other types of math games nor does it indicate what teachers should do once children are competent on the 10-space game.

Other games. Game-based instruction has been considered as the teaching method which could best induce students' learning motivation because games present active activity that the learning process could be designed as interesting as games; it is therefore an ideal learning method (Lai et al., 2010). Applying games to learning situations not only could enhance fun, but also induce children's learning motivation through the challenge and excitement of games so as to acquire continuous irritation. Yoon (2014) argued that games could break the ice between learning goals and teaching tactics as well as reduce teaching seriousness so that children could freely develop the creative thinking in the learning process. The function of games and the meaning of education have been affirmed by experts. With the fun from games, children could complete learning goals in thinking and experiencing and satisfy the fun of gaming and learning that it is a meaningful activity (Meuris et al., 2014). Blackwell et al. (2015) agreed with the great benefit of digital games to teenagers' learning motivation. Huang et al. (2013) discovered that gamers would be induced psychological reactions of higher intrinsic learning motivation in computer game situations and under the atmosphere of competition or cooperation. Viggiano et al. (2015) also mentioned that matching computer games with animation software could have children develop the understood scientific concepts, create experimental results, and enhance learning motivation. Chen (2017) studied the effect of game basesd instruction on learning achievement and motivation as well as the relation between learning motivation and learning achievement. In all the cases, there were a noticeable differences and correlation between the variables.

Digital game is a kind of teaching technology, as digital games present challenge and fantasy and could induce pupils' curiosity; besides, the feedback in the playing process could enhance pupils' learning knowledge (Manesis, 2020). Sancar-Tokmak (2015) indicated that computer games could enhance high-grade pupils' creativity, problem-solving ability, and achievement motivation. Cheng et al. (2012) considered that computer games could train a person's induction skills. Game-based instruction is an educational game program designed by integrating teaching content and game characteristics. Yoon (2014) stated that a game program could induce a learning cycle, including allowing learners making judgment and practice and having the system give feedback. Such a cycle allows learners feeling happy and being willing to continuously spending time on such a learning cycle; besides, continuously participating in such games could achieve certain training goals or specific learning outcome. Such a game-based learning model also corresponds to that good educational game design should have good learning scaffolding to facilitate learners' learning. It seems to be the second step in the model that good educational games should know how to construct a learning cycle attracting learners' continuous learning (Huang et al., 2013).

Snow et al. (2013) also discovered that students who played the computer game of Newton's mechanics could more correctly answer questions related to object movement and force than those who did not play such a game. Besides, Yoon (2014) indicated that computer games could enhance students' performance on algebra learning, reading ability, problem solving thinking ability, strategic planning ability, cooperation ability, and self-learning regulation ability and presented great benefits on the learning motivation and learning achievement (Cheng et al., 2013). Yang et al. (2012) mentioned that the content design of computer games, in addition to the characteristics of setting goals and setting game rules, presented challenge, in which players had to achieve tasks with distinct strategies for challenge containing different types of competition and cooperation, and included some imagination to induce gamers' curiosity, and induced learning motivation with entertainment so that gamers were willing to proceed meaningful and discovery learning.

With respect correlation, as per Chen (2017), learning motivation presents significantly positive effects on learning effect in learning achievement, indicating intrinsic orientation and extrinsic orientation show remarkable effects on learning effect. Besides, the correlation analysis of learning motivation and learning harvest show tha intrinsic orientation and extrinsic orientation reveal notable effects on learning harvest.

Moreover, van der Ven et al.(2017) conducted an experimental study to investigate the effectiveness of a tablet game on increasing arithmetic fluency in an engaging manner. The intervention of a table game was engaging and had a significant positive effect on dot-subtraction efficiency. The latter suggests that playing with the game benefitted the calculation operation, rather than retrieval speed or a switch from calculation to retrieval due to memorization. Possibly, calculation efficiency is improved by the intervention because,

i) teaching of dot subtraction is done by using calculation rather than retrieval, more so than the other measured arithmetic types, and

ii) the dot problem-answer representations were not trained during the intervention. Contrary to the expectation, no effect is registered on Arabic-arithmetic fluency. Possibly, the number of memorized Arabic problem-answer representations was already at ceiling level, or alternatively the intervention was too short to promote the memorization of these representations.

The findings from van der Ven et al.(2017) suggest that an arithmetic fluency tablet intervention can benefit calculation efficiency, probably by training mathematical insight. The tablet game focused on speeded responses, but also the relationships between quantities were trained (e.g., 9-5 = 8-4 = 4). This knowledge about part-part-whole relations could have encouraged the use of transformation strategies (LeFevre et al., 1996) in which the child uses re-grouping tricks for calculating the answer (e.g., 9-4 = 8-4+1) as an efficient alternative to counting (Hunting 2003; Baroody et al., 2009). Adults mainly use a combination of calculation and retrieval (Imbo & Vandierendonck, 2008), which may be most advantageous for good mathematics: One cannot memorize all possible sums, and calculation methods are crucial when retrieval fails. It is important to note that the effect of the intervention disappeared after the disuse of the tablet game. The influence of the game on arithmetic skills could be larger and more persistent if the intervention period is prolonged with additional playing sessions (Clark et al., 2015). On a practical level, a tablet game can be a fun method for improving calculation skills. In this regard, the current game can be used as a useful addition to, not a substitution for, grade 1 arithmetic-education. Caution is warranted.

With respect to its effect on motivation, researchers who support game-based instruction note that a game, can provide a rich environment in the context of game-based instruction, can serve as a powerful medium for improving motivation, and can enhance students' cognitive competence, spatial competence, and creativity (Chen et al., 2019). Accordingly, digital games can be used to create effective learning environments (Robertson & Howells, 2008). Liu et al.(2011) indicated that the digital games' challenging nature and feedback mechanisms plays an important role to minimize learning anxiety, encouraging them to identify solutions through trial and error or imitation or to elicit motivation from demotivated learners. The educational relevance of such games has been widely studied (Hong, 2009). Sardone and Devlin-Scherer (2009) investigated how digital games improve the learning outcomes of children aged between 6 and 12 years; the children reported that the games encouraged them to learn about difficult subjects, provided an interesting perspective on problem-solving, facilitated learning, and strengthened their interest in the subject matter. Several studies have also asserted that game-based instruction promotes learning interest and motivation (Hawisher& selfe, 2016). These studies indicate that enacting mathematical instruction via game and activities plays a paramount role to use of all sense organs in learning process, enhances interest, provides motivation, offers the opportunity of active participation and permanent learning (Turgut & Dogan Temur, 2017).

In conclusion, this dissertation attempts to investigate how this cultural math game board, as an instructional media with some modification and /or as it is, helps as an instructional media for students with MD to progress and to be motivated to learn mathematics. There are different ways of playing the game in Ethiopia, like what was mentioned before. If this study is successful in this track, it will be a best alternative of teaching counting and arithmetic in the primary schools..

Explicit Instruction and Its Effect.

What is explicit instruction? As noted by Archer and Hughes (2011), explicit instruction is defined as direct instruction, which is designed to be explicit is characterized by three stages:

a. Models and demonstrations are needed to be delivered in a clear way.
b. Teachers support and guide students’ practice by giving corrective feedback delivered in a timely manner,
c. Finally, moving students to perform tasks independently by gradual withdrawal of teacher’s supports during practice.

Then, instructional procedures include sequencing instruction, providing instructional routines (e.g., presentation of subject matter, guided practice, and independent practice), focusing on massed practice, teaching to criterion, and evaluating student learning on a regular basis (Swanson, 2001). Explicit instructional strategies are dynamic and interactive in a relationship that mandates flexible and responsive instruction (Villaume & Brabham, 2003). Research findings on the benefits of explicit, strategic instructional procedures are well documented in the mathematics disability literature (Fuchs et al., 2008; Gersten et al., 2005). Gersten et al. (2009) highlighted explicit instruction, use of strategies, student verbalizations, use of visual representations, progress monitoring, and using a variety of examples as important instructional practices for students with MD. For instance, Bryant et al. (2011) conducted a study on first-grade students with MD on an early numerical competencies assessment, by assigning some students (n = 151) to an early numerical program, while the rest of students (n = 73) stay in their regular education classroom for mathematics instruction.The findings of this study indicated that students who participated in the early numerical program, utilizing explicit instruction with guided and independent practice, achieved significantly better than students in the control group, registering 0.18 effect sizes (ES) of on magnitude comparison, 0.47 on number sequences, and 0.55 on addition and subtraction number combinations, and 0.39 on place value.

Another single subject experimental work on exploring the use of explicit instruction in teaching young children counting skills using received instruction for resultative counting and shortened counting, students showed improvement in counting skills (Hinton et al., 2015). Counting is the most basic skill required to build number sense. Explicit instruction that utilizes objects and pictures has been found by researchers to improve skills that range from place value of numbers to algebra equations (Flores, 2010; Kaffar & Miller, 2011; Strozier, 2012). Researchers also showed explicit instruction is very versatile and, therefore, has potential in counting instruction.

Furthermore, the most related study specific to mathematics difficulty, Beygi et al.(2010) examined the performance of two mathematical operation viz., addition and subtraction, presents the means and standard deviation of experimental and control groups in pre/post-tests **.** The outcome of this study portrayed significant improvement in the addition test performance after remedial intervention for experimental group. Similarly, in the case of subtraction, the ANCOVA showed significant improvement in the subtraction test performance after remedial intervention for experimental group. Thus the significant improvement observed in the experiment group that underwent remedial teaching proved the effectiveness of the remedial program employed in the study. The results are in agreement with Gowramma (2005) and other researchers (Kroesbergen & Van Luit, 2003).

Elements of Explicit Mathematics Instruction. Despite having various meaning in the literature review (Gersten et al., 2009), the three elements of explicit instruction would be most commonly agreed which includes teacher modeling, guided practice opportunities, and academic feedback.

i) Clear Teacher Models

As to Coyne et al.(2011) effective teacher models show students exactly what math content they will learn and how they will apply it. There is strong evidence that supports the use of teacher models when teaching students with MD. In a more recent meta-analysis, Gersten et al. (2009) analyzed 42 studies involving students with math disabilities and found that the most effective interventions were ones that provided step-by-step demonstrations for solving math problems. Taken together, before taking guided and/or independent practice, these studies suggest that students with or at risk for MD are more successful in acquiring new math knowledge when directly shown what to do of such newly learned skills or concepts.

In the example, the teacher explains step-by-step how to solve a multi-digit problem involving addition without regrouping. Wu (2009) shows that the task of the teacher is first identifies the kind of problem and then catches the attention of the students to how multidigit problems merely consist of simple, single digit computations. Next, the teacher solves the problem in the ones column followed by the problem in the tens column. For each single-digit computation, the teacher emphasizes how to vertically align the numbers in the appropriate column.

Archer and Hughes (2011) offer three strategies for improving the effectiveness of teacher models. First, they recommend that teachers use precise wording to communicate both simple and complex ideas to students. Second, they recommend that teachers structure instructional interactions that emphasize the active participation of students in the learning process. Finally, they suggest that a sufficient amount of teacher demonstrations be provided so that students clearly understand the learning objectives for the lesson and what proficient performance looks like. These three strategies are pretty important to provide teachers with a framework and to help access for students with MD to the critical content of beginning mathematics.

ii) Guided Practice

Similarly, guided practice in the classroom supports students during the early stages of math learning. Supporting students is gradually decreased and systematically withdrawn, when students reach more proficient with a particular math concept or skill. Over the years, researchers have identified aspects of effective guided math practice (Archer & Hughes, 2011; Chard & Jungjohann, 2006; Doabler et al., 2012). These aspects can be summarized in the following ways. First, *identify and pre-teach prerequisite skills*, in this case teachers should ensure that students have the prerequisite skills necessary to be successful in the new content (Kame'enui & Simmons, 1999). To help prepare students, prerequisite skills should be addressed prior to the introduction of more advanced content. Secondly, *select and sequence instructional examples*. (Chard & Jungjohann, 2006). To best support initial instruction, teachers should use instructional examples that are easier for students to solve and understand. Judicious selection of instructional examples will help students ease into new math content. Thirdly, *use verbal prompts*, teachers can prompt students to answer math related questions and explain solutions to problems. For example, a teacher might ask a student by saying "Lucia, could please tell how can you represent 73 with the place value blocks." Teachers should use verbal prompts to initiate student math reasoning and facilitate richer math-centered discourse. Then the teacher can use the prompts such as a clap, finger snap, or verbal cue , to express admiration. Fourthly, use multiple representations of math ideas**,** math manipulatives are pictorial and concrete representations of math ideas. When used appropriately, as with most instructional tools, utilizing manipulatives are helpful for students to develop a fundamental understanding of math concepts and skills (Gersten et al., 2009; Hudson & Miller, 2006; Van de Walle, 2001). Teachers can incorporate math models into their teaching routines by using a CRA sequence. Under the CRA sequence, a teacher might use 10 bundles, each with 10 straws, to represent 100. Finally, the time at which students demonstrate knowing of 100, fading out the manipulatives and transition to abstract symbols (i.e., numbers) are done. Fifthly, *provide cumulative review*, Carnine (1997) explicate that cumulative review helps for both teachers and students. For teachers, it plays a role to get an ongoing information on whether students are retaining previously learned concepts or skills and for students, it is a way to help students remember and maintain math skills that have been taught previously. For example, if students were learning how to add two two-digit numbers, an effective review would also include addition problems that involve single-digit numbers.

iii) Academic Feedback

Hudson and Miller (2006) indicated that academic feedback is used to affirm and, when required, correct student responses. In order to minimize the potential for misunderstandings and deepen student understanding of math concepts and skills, giving invariant academic feedback is important (Doabler et al., 2014). The time of giving feedback matters in a sense that errors are easier to mend the earlier they are acknowledged (Stein et al., 2006). When teachers correct student errors, they should use language that is positive in nature and specific to the mistake. In particular, they should state the correct response and then provide a second practice opportunity to the student or group of students who made the mistake. Having positive academic feedback is paramount important to let students know that they are on track and can be successful in doing mathematics (Kilpatrick et al., 2001).

Who Can Benefit From Explicit Math Instruction? Generally speaking, students without MD are able to solve math problems fluently and accurately. For students with MD, becoming mathematically proficient can be challenging, both conceptually and procedurally. So, the explicit math instruction can be highly significant for students with MD (Doabler & Fien, 2013).

In conclusion, to meet the needs of students struggling with mathematics, efforts will require the delivery of evidence-based math instruction in general education classrooms and small group interventions. The use of explicit math instruction in both educational settings will likely strengthen these efforts. By drawing from the final report of the NMAP (2008) and the research literature on effective math instruction, Doabler and Fien (2013) provides guidelines that teachers can use to improve the quality of math instruction for students at risk for math failure by making daily math instruction more explicit and systematic.

Other Methods of Instructional Intervention and Their Effects. Researchers have offered recommendations for prevention and intervention for students with MD, including peer-assisted tutors (Baker et al., 2002), verbalizations of cognitive strategies (Fuchs & Fuchs, 2001), and physical (concrete) and visual (pictorial) representations of number concepts (Gersten et al., 2005). Findings from studies on students with MD support the use of explicit, strategic instruction in teaching procedural and conceptual knowledge (calculations principles, commutative property of addition, counting strategies (Butler et al, 2003). In addition, based on experimental work with students with MD, Fuchs et al. (2008) provided several recommendations for important components of mathematics instruction. According to him, instruction should be explicit with a focus on conceptual and procedural knowledge.

2.6.3. Effect of Early Numerical Interventions on Working Memory or Retention

Former researches on intervention practices for typical developing students, (Jitendra et al., 2007; Jitendra et al., 1998) supplied evidence to support the hypothesis related to students' getting mathematical intervention for relatively long time exhibited better retention of problem solving over control students. More specifically, Nejem and Muhanna (2014) studied the effect of using smart board on mathematics retention of students by measuring using the retention test to both the control group and the experimental group. The findings of this study show that there is a statistically significant difference between the means of the control and the experimental groups in the retention test. This difference is in favor of the experimental group that studied mathematics using smart board had higher retention than that of control group.

Contrary to the aforementioned prior researches but on children with MD, Jitendra et al (2014) studied the impact of small-group schematic based instruction (SBI) tutoring on the mathematics achievement and retention of third-graders at risk for MD. The outcomes of their findings indicated that there is no a statistically significant difference between the means of the control and the experimental groups in the retention test. They put the following potential explanation. One potential explanation for the lack of significant effects is that these students needed a longer intervention with more opportunities to practice the learned content to produce lasting effects. Students in the present study received tutoring for 12 weeks, which is consistent with similar previous studies (Jitendra et al., 2007; Jitendra et al., 2013). However, unlike previous SBI studies (Jitendra et al., 2007; Jitendra et al., 2013), the word problem solving content in the present study was reduced to include teaching of foundational skills and fluency with addition and subtraction number combinations, which may have had an impact on the retention of word problem solving skills. Another possible explanation for the lack of significant effects of retention of word problem skills has to do with the amount of elapsed time between the conclusion of tutoring and administration of the delayed posttest. Jitendra et al. (2014) assessed retention of word problem skills 8 weeks post intervention, whereas other similar studies assessed maintenance at one (Jitendra et al., 1998) to six weeks (Jitendra et al., 2007; Jitendra et al., 2013) post intervention.

As per EGMA of Reubens (2009),children begin to store information in memory over time with practice. At first, children may retrieve the answer to a mathematics problem but may not yet have confidence in their answer. With practice, children gain confidence and process information faster in solving mathematics problems. Children may also build confidence in the use of fact retrieval for simpler mathematics problems, such as retrieving knowledge for numbers of equal value such 2 + 2 = 4 (Siegler & Shrager, 1984). But note that there is a level of "automatization" of the knowledge that "2 + 2 = 4" that is preceded by a conceptual stage that requires counting. At the same time, becoming efficient at mathematics does require the automatization of the subsequent stage, rather than a constant recursion to the earlier stages. For more difficult mathematics problems, this extended practice provides the skills and proficiency needed for rapid and accurate processing, freeing up cognitive resources so that children are able to pay attention to more elements of the task at once (Pellegrino & Goldman, 1987). For that reason, children who demonstrate difficulty with single-digit items such as "5 + 6" will find more advanced mathematics more challenging (Gersten et al., 2005). In other words, recursion to more primitive strategies, though it does show understanding of the concept, might impede further conceptual understanding and progression if operational automaticity is not achieved.

2.6.4. Individual Educational Program (IEPs) and Target Setting for Numeracy

What is an IEP?An IEP is a documented plan developed for a student with special needs that describes individualized goals, adaptations, modifications, services to be provided, and measures for tracking achievement. It must include the goals or outcomes set for that student for the school year, if they are different from the learning outcomes set out in an applicable educational program or guide. An IEP usually list supports required to achieve goals established for the student and significant adaptations to educational materials, instructional strategies or assessment methods. It documents the special education services being provided as they relate to the student's identified needs and how those services will be delivered. According to MOE and BCSSA (2011), IEP assists with:

Planning

- Formalizing the decision making process
- Providing a collaborative tool for all people involved, including parents and students.
- Linking formal and informal assessment results with programming strategies
- Providing guidance about transitions

Tracking

- Serving as a tool for monitoring individual student learning
- Providing an ongoing record to assist with continuity in programming, and

Recording

- Providing a record for the student's file and all involved about the student's special education program, and

- Serving as the basis for reporting the student's progress on goals and objectives.

IEP for Specific Learning Disabilities. IEPs do not describe every aspect of students' education programs, but they should describe those aspects that require individualization. IEPs reflect the complexity of students' learning profiles; they might be brief or more detailed. For example, the IEP for a student who needs adaptations only for taking tests might be relatively simple. In contrast, a student with a complex array of accommodations and interventions requires a more extensive IEP. Because students with learning disabilities by definition have average or better ability, IEP goals should be set at a high but attainable level (Reschly, 2005). Individualized learning outcomes typically focus on the acquisition of basic skills (e.g. literacy or numeracy skills) and the development of compensatory and learning strategies. Socio-emotional goals focusing on such things as self-esteem and friendship skills might also be included. IEPs might also identify strategies for minimizing the impact of learning disabilities and skill deficits.

When target setting, it is vital that the specific area of difficulty is identified and **SMART** targets are written. (**S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**ime limited).

- Targets should be based on diagnostic assessment which includes individual skills, structures and learning styles.
- Targets should be shared and agreed with learners and parents/careers.
- Target setting for numeracy should consider the widest range of focus areas.
- Evaluation of targets should be based upon the learners' response to the teaching methods, approaches and measurable progress made in the specific focus area.

2.6.5. Early Numeral Instruction: Examples of SomeResearches

Research findings and intervention syntheses (Baker et al., 2002; Kroesbergen & Van Luit, 2003) offer insight into practices and materials that hold promise for teaching young students who struggle with early mathematics, despite the fact that the number of studies is limited. Researchers have offered recommendations for prevention and intervention, including peer-assisted tutors (Baker et al., 2002; Fuchs et al., 2001), verbalizations of cognitive strategies (Fuchs & Fuchs, 2001), and physical (concrete) and visual (pictorial) representations of number concepts (Fuchs et al., 2001; Gersten et al., 2005), explicit instruction (Gersten et al., 2009), game based instruction (Wan Ahmad et al., 2010), computer-assisted instruction (e.g., Seo & Woo, 2010), mnemonic strategy instruction (Manalo et al., 2000), schema-based instruction (Jitendra et al., 2002), cognitive strategy instruction (Montague & Dietz, 2009), representations (Jitendra et al.,2016), and the CRA instructional framework (Kim, 2020; Hinton &Flores, 2019). Based on interventional experimental work with students who struggle with mathematics, only few examples of some experimental researches were reviewed, by briefly touching participants and sampling, the design, the experimental conditions and major findings from studies on students with MD.

First, the experimental study on the effect of using the CRA on mathematics skills is explicated. Miller and Kaffar (2011) explored the effectiveness of using the CRA teaching sequence with integrated strategy instruction for developing addition with regrouping competence among students with MD. A total of 16 lessons were provided to 24 students during a six-week summer program. On both computation and fluency, students who received CRA with integrated strategy instruction performed better than comparison students. Nevertheless, on word problems and a discrimination/review measure, there is a similar performance between the two groups. A similar study based on CRA, Flores (2009) investigated the effects of the CRA instructional sequence on the computation performance of students with specific learning disabilities and students identified as at risk for failure in mathematics. As indicated by researchers, for teaching basic mathematics facts, fractions, algebra, and place value, utilizing CRA sequence is effective. Therefore, Flores examined the effects of CRA instruction on elementary school students' fluency in computing subtraction problems with regrouping and maintaining these skills, using a multiple probe-across-groups design and demonstrated a functional relation between CRA instruction and subtraction with regrouping across all students. It is concluded that the CRA instructional sequence provided the students with a scaffold from conceptual understanding to procedural knowledge in which the students became fluent. On the other study, for typical developing students, Ching and Wu (2019).examined the effectiveness of various instructional strategies that aimed to enhance children's understanding of the inversion concept. They randomly assigned a number of students to each of the following groups namely: (a) concrete-only, (b) abstract-only, (c) concreteness fading, (d) abstract-to-concrete, (e) control. The students participated in three session time, a pre-test, two training sessions, an immediate post-test, and an 8-week delayed post-test. The findings from this study demonstrated that in comparison with the control group, all the intervention groups showed significantly greater progress in solving the inversion problems in the post-tests. The study of Ching and Wu (2019) suggest using concrete representations is very important in teaching mathematics to children and should not be avoided; and the sequence of presentation for various representations plays a key role for successful learning. Hence, CRA instructional framework is a graduated instructional sequence that supports students in mathematics and its sequence is effective in teaching mathematics interventions for students with MD

Second, explicit instruction also has been identified as one the most effective approaches for teaching students with MD (NMAP, 2008). This is supported by Gersten et al. (2009) indicate that explicit instructitin of mathematics interventions underscore this beneficial impact. For instance, Clarke et al. (2011) studied the effect of eaarly Learning in Mathematics with an explicit instructional focus. Clarke et al. found kindergartners at risk for math failure in the treatment classrooms made significant gains relative to their at-risk peers in control classrooms. Of interest, at-risk students in the treatment classrooms also narrowed the achievement gap with their typically achieving peers. Bryant and colleagues (2008) explored the impact of a Tier 2 small-group intervention on the math achievement of at-risk first graders. Participants in the study had demonstrated difficulties in their general education classrooms (Tier 1) and thus were deemed as being at risk for MD. At the intervention's conclusion, the findings supported the use of explicit and systematic instruction for improving students' ability to solve place value problems and to answer addition and subtraction facts. In a more recent Tier 2 study, Dyson et al. (2011) tested the effects of an 8-week intervention on kindergarten students' understanding of whole-number concepts. The intervention, which supplemented the students' core math program, provided 30 minutes of small group instruction, 3 times per week.

Third, explicit instruction with the other methods, Gersten et al. (2009) highlighted explicit instruction, use of strategies, student verbalizations, use of visual representations, progress monitoring, and using a variety of examples as important instructional practices for students who struggle with mathematics.. Compared to early reading intervention research, there is a paucity of research on early (first- and second grade) Tier 2 intervention to prevent mathematics disabilities in struggling students and to address the difficulties young students are experiencing in mathematics instruction (Gersten et al., 2005). The majority of mathematics studies that are available focuses on research for older students with math disabilities or low achievement (e.g., Fuchs et al., 2003). A few studies were identified that conducted whole class instruction, typically Tier 1 instruction with younger students. For example, whole-class intervention programs, such as Number Worlds and Peer Assisted Learning Strategies (Fuchs et al., 2001), provide effective practices for teaching numeracy skills to low-achieving students.

Fourth, based on the early number program, Fuchs et al. (2005) render early numerical tutoring by assigning students randomly to a group that receive early numerical tutoring and a group that participate in their regular mathematics instruction without tutoring. Students received tutoring for 16 weeks, three times a week, 40 minutes a session. The outcome of the study demonstrates that students who received tutoring performed better than students without tutoring on tests of calculation ES of 0.57, addition facts ES of 0.40, subtraction facts ES of 0.14, concepts and applications ES of 0.67, and story problems ES of 0.70. Kaufmann et al. (2003) worked in an early numerical program with six students with MD for 6 months, three times a week, 25 minutes a session. Students learned about counting, symbols, facts equal to 10, addition and subtraction facts, and place value through explicit instruction and working from the concrete (i.e., manipulatives) to the abstract (i.e., solving problems with numbers and symbols). The six students enjoyed strong growth over the course of the program compared to peers without MD. Expanding this work by Kaufmann et al.(2005), they compare an early numerical program focused on procedural and conceptual learning versus a program focused on training of basic skills. The findings of their study show that the group with the procedural and conceptual program outperformed on students who participated in the basic skills program such as counting, cardinality, comparisons, and calculations. Besides, Van Luit and Schopman (2000) worked with kindergarten students on an early numerical measure by assigning students in early numerical instruction; and the rest in their regular classroom program. Based on Hudson and Miller (2006), the method of teaching of early numerical instruction is explicit and interactive and followed a sequence of concrete to representational to abstract, and focused on counting skills. The findings of their study show significant gains for students who participated in the early numerical program in comparison with control students on early numerical measures of comparing numbers, counting, and understanding the meaning of numbers. All the instruction in these programs was explicit and focused on teaching students the meaning (i.e., concepts) behind early numerical competencies along with the procedures to solve mathematics problems.

Fifth, Noda and Tanaka-Matsumi (2017) carried out single subject experimental design on the efficacy of number family instruction on improving fluency of addition and subtraction facts. Their finding pointed out that enacting number family instruction plays enormous role improving the fluency of addition and subtraction facts in elementary school students. . The results provide additional support for evidence-based educational programming in basic mathematics. Teaching number families may contribute to the effective remediation of computation skills in students with academic difficulties.

Collectively, the above mentioned experimental studies support the notion that students with MD benefit from instruction that is systematically designed, utilizing CRA and explicitly delivered. If the classroom teachers fail to provide explicit math instruction on a regular basis, it most probably makes students with MD to continue to struggle to learn mathematics (Gersten et al., 2009; NMAP, 2008).

2.6.6. Mathematical Instructional Strategies

Counting Instructional strategies. The followings are the general strategies for teaching counting; these are not specific grade-level descriptions. According to the Ontario Ministry of Education (2003), the interventionists or teachers should:

- link the counting sequence with objects (especially fingers) or movement on a number line, so that students attach the counting number to an increase in quantity or, when counting backwards, to a decrease in quantity;
- model strategies that help students to keep track of their count (e.g., touching each object and moving it as it is counted);
- provide activities that promote opportunities for counting both inside and outside the classroom (e.g., using a hopscotch grid with numbers on it at recess; playing hide-and-seek and counting to 12 before "seeking"; counting students as they line up for recess);
- continue to focus on traditional games and songs that encourage counting skills for the earliest grades but also adapt those games and songs, so that students gain experience in counting from anywhere within the sequence (e.g., counting from 4 to 15 instead of 1 to 10), and gain experience with the teen numbers, which are often difficult for Kindergarteners

- link the teen words with the word ten and the words one to nine (e.g., link eleven with the words ten and one; link twelve with ten and two) to help students recognize the patterns to the teen words, which are exceptions to the patterns for number words in the base ten number system; quality
- help students to identify the patterns in the numbers themselves (using a hundreds chart). These patterns in the numbers include the following:
  - ✓ The teen numbers (except 11 and 12) combine the number term and teen (13, 14, 15).
  - ✓ The number 9 always ends a decade (e.g., 29, 39, 49).
  - ✓ The pattern of 10, 20, 30, . . . follows the same pattern as 1, 2, 3, ...
  - ✓ The decades follow the pattern of 1, 2, 3, . . . within their decade; hence, 20 combines with 1 to become 21, then with 2 to become 22, and so on.
  - ✓ The pattern in the hundreds chart is reiterated in the count from 100 to 200, 200 to 300, and so on, and again in the count from 1000 to 2000, 2000 to 3000, and so on.

Addition and subtraction strategies. Number concepts are simple arithmetic problems (e.g., 5+7=12; 9-5=4) that can be solved via counting or **decomposition strategies** or committed to long-term memory for automatic retrieval. Consensus exists that number concept skill is essential (Kilpatrick et al., 2001), with evidence that fluency with number concepts is a significant path to procedural computation and word-problem performance (Fuchs et al., 2006). A common pattern of development competence with number concepts s involves children gradually gaining efficiency with counting strategies. During addition, letting children initially count two sets (e.g., 2+3) in their total (i.e., 1, 2, 3, 4, 5). This strategy is called **the sum counting strategy (or counting all)**.

Missing-addend counting strategy for subtraction. To solve subtraction number combinations, students often count down. That is, they start with the minuend and count down the amount of the subtrahend. For 9 – 4 =, students start with 9 and count back 4: "8, 7, 6, 5." Counting down or counting backwards is difficult for students, especially students with MD, because fluency with counting backwards is limited compared to fluency counting forward (Passolunghi & Cornoldi, 2008). Counting backwards makes students to do many more mistakes than counting forwards. So, in order to solve subtraction, utilizing counting up is a more efficient strategy. Students begin from start with the subtrahend and end up count to the minuend. For instance, 9 – 4 = __, then students begin from the subtrahend 4 and count, "5, 6, 7, 8, 9." .This strategy is the most supportive for students with MD making them to develop quick forward-counting skills (Fuchs et al., 2009; Fuchs et al., 2010).

Finally, according to Geary et al. (2007) students with mathematics disability manifest greater difficulty with counting; exhibit constant immature back-up strategies (Geary et al., 2007); and show up difficulties to make the shift to memory based retrieval of answers. Retrieving answers from memory, children with MD do more errors and exhibit more unsystematic retrieval speeds than younger, in comparison with their counterparts (Shalev et al., 2000). Some consider number concepts to be a signature deficit of students with mathematics disability, and a deficit in automatic retrieval of Number concepts is one of the most consistent findings in the mathematics disability literature (Cirino et al., 2007; Geary et al., 2007; Jordan, Hanich, & Kaplan, 2003)

2.7.*Mathematics Difficulties: Early Mathematics Instructional Content*

Finding out the appropriate early mathematics instructional content for children with mathematics difficulty is enormously important**.** It is apparently known a great deal about effective instructional procedures for teaching struggling students, and there is compelling evidence to focus on foundation skills in early mathematics instruction at the primary level (Clarke et al., 2015). The emerging database about early mathematics intervention is promising but remains limited in scope compared to the availability of research-validated early reading intervention. Thus, there is a need for studies to validate early mathematics for students at risk for mathematics disabilities. The intention is just to identify students who are demonstrating MD and to provide intervention to prevent future learning difficulties. As per Bryant et al.(2008), in thinking about mathematics skills and concepts to target for early intervention, it must be mindful of findings from predictive studies about the mathematics characteristics of young, struggling students (e.g., difficulties with number-sense tasks and arithmetic combinations), based on intervention work on the early numeracy literature that describes skills that are problematic for students with MD, mathematics lesson standard, as well as principles and standards for school mathematics.

In their instructional work, Bryant et al. (2008) utilized booster lesson. The intent was to “boost” student learning in the area of number, operation, and quantitative reasoning by providing systematic, explicit intervention in small groups during the school day. These were supplemental to core mathematics instruction, which ranged from 45 min to 60 min of instruction on the designated skill areas (e.g., measurement, problem solving) for the week. Content for the booster lessons was based on the number, operation, and quantitative-reasoning skills and concepts from the Texas Essential Knowledge and Skills (TEKS) standards. The mathematics TEKS are rooted in the *Principles and Standards for School Mathematics* from the National Council of Teachers of Mathematics (2000).

The conceptual framework for first- and second grade number, operation, and quantitative reasoning used to guide the development of booster lessons as listed by Bryant et al. (2008).

- **Number concepts**
  - ✓ Counting: rote, rational, counting up or back, skip (2, 5, 10)
  - ✓ Number recognition and writing: 0–99 (first grade); 0–999 (second grade)
  - ✓ Comparing and grouping numbers: number relationships of more, less; relationships of one and two more than or less than, anchoring numbers to 5 and 10 frames; part-part-whole relationships (e.g., ways to represent numbers)
  - ✓ Numeric sequencing
- **Base 10 and place value**
  - ✓ Making and counting: groups of 10s and 1s (first grade); groups of 100s, 10s, and 1s (second grade).
  - ✓ Using base-10 language (three 100s, zero 10s, six 1s) and standard language (306) to describe place value
  - ✓ Reading and writing numbers to represent base-10 models
  - ✓ Naming the place value held by digits in numbers.
- **Addition and subtraction combinations**
  - ✓ Identity element and properties
  - ✓ Fact families
  - ✓ Counting and decomposition strategies (e.g., addition: count on [+0, +1, +2], doubles, doubles +1, make 10 + more; subtraction: countdown [–0, –1, –2, –3], count up; number bonds)

The booster lessons were designed on the basis of practices identified as critical for students who are at risk for or have identified MD with the following features.

First, a combined instructional approach employing explicit, systematic teaching procedures and strategic instruction was implemented. To deliver the scripted booster lessons , procedures such as modeling, “thinking aloud,” guided practice, pacing, and error correction were used. During modeling, tutors demonstrated the processes or steps needed to solve problems or provided explanations of how to perform skills. Strategic instruction focused on teaching students specific strategies for learning addition and subtraction combinations. Guided practice activities consisted of multiple opportunities to practice skills and concepts including reading, writing, and “making” numbers within a given number range (described below).

Second, the instructional content was controlled during a 2-week instructional time period. Within an instructional 2- week time period, booster lessons were provided on skills and concepts related to number concepts, base 10 and place value, and addition and subtraction combinations. Particularly, emphasis was placed on those number concepts that prove problematic for students with MD (e.g., teen numbers, zero as a place holder). Also, within each 2-week time period, a designated number range was targeted that represented a smaller unit of the identified number range for that grade level. For example, numbers 0 through 99 were taught in first grade, so a unit of instructional content for first grade for a 2-week period might include numbers 10 through 20. Numbers 0 through 999 composed the curriculum is for second grade; numbers 100 through 200 is the instructional number range for a 2-week period. Instructional content for addition and subtraction combinations included sums or minuends ranging from 0 to 18 and sequenced from easier (e.g., addition facts +0, +1, +2; subtraction facts – *n*, – 0, – 1) to more difficult (e.g., addition facts doubles +1 [6 +7], make 10 + more [9 + 7]; subtraction inverse facts) combinations. Addition and subtraction combinations were taught separately, with the easier combinations for both preceding the more difficult ones.

Third, as appropriate, the concrete–semi-concrete–abstract (CSA) approach (Butler et al., 2003) was used to teach number concept and relationships, base 10 and place value, and addition and subtraction combinations. They used a variety of instructional materials with this approach. For example, at the concrete level, base-10 models and counters were used to teach concepts and skills. For the semi-concrete level, we used number lines and 100s charts. Finally, the abstract level focused on the manipulation of numerals. Also, the levels were mixed so that students might manipulate base-10 models to make numbers, read numbers, and write numbers of concrete model representations. Finally, the majority of students in the group had to demonstrate accuracy on three out of four of the problems to consider the lessons as successful for each day.

. Followingly, the early instructional content, Smith (2010) grouped the basic and predictive skill sets of early grade mathematics into counting concept and number sense constructs. Counting concept and number sense in early grade mathematics are described.

Counting Concept refers to the understanding of principles of correspondence between number words (like one, two, and three) and quantities (Smith, 2010). Gelman and Meck (1983) listed out five principles by which we can measure the level of understanding of counting. These are:

a) One-to-one correspondence principle refers to the creation of unique connection between counting objects and number symbols or words.

b) The stable order principle refers the order of number words remains the same at all times when the child counts. Example, all the time the number *three* precedes the number *two* - no condition alters the order of these numbers.

c) The cardinal principle, the last number in a counting sequence indicates the total number of objects counted or in a set (Bermejo et al., 2004).

d) The order irrelevance principle, the counting arrangement does not affect the number of objects or the cardinal value provided that all elements of the set are counted. In the stable order principle the issue is about the number words which are always fixed irrespective of the numeration system. In the case of order irrelevance principle, the idea is about the order of elements to be counted. As described above, though six comes after five and that is fixed, the objects used to count could be arranged in any order. Thus, it refers to the understanding that there is no inherent relationship between a number and an object in the counting though the object should not be missed out.

e) The abstraction principle, the objects used for counting purposes do not affect the counting or the quantity. That is, counting using candles or pictures of lions or actual flowers is all the same and does not change the quantity.

Smith (2010) added the Number Sense category of skills refers to the development of number ability as opposed to the level of comprehension or understanding of number concepts or principles. This category shows the early grade mathematics learning has four subtasks:

i. **Number Identification,** the correspondence between number sound (word) and number symbol, like the case in the relationship between letter symbol and letter sound - graphophonemic awareness.

ii. **Counting Skill**, the ability to use number words in counting (objects) orderly and specifying numbers or quantities. This counting skill is more of counting procedure driven and can be accomplished with some kind of counting principle in mind.

iii. **Understanding Magnitude**, this is the ability to identify numbers and limit the magnitude in a comparative manner - which set has more elements.

iv. **Operation on numbers**, adding, subtracting, multiplying and dividing numbers of age or grade appropriate.

The two constructs (counting concept and number sense) are stand by their own and mutually dependent. The counting concept component promotes the understanding of counting abilities, system of counting and quantity identification. The Number Sense deals with the skills involved in counting, connecting symbols and number names, comparing quantities, and the technicalities of operations.

Understanding how to count does not necessarily equip the individual with the ability of counting as the later requires task-based practice. On the other hand, proficiency in computational skills should be supported by adequate and relevant conceptual understanding of the background knowledge. It is the appropriate integration between knowledge acquisition and computational skills that produce number, operational and problem solving competencies (National Council of Teachers of Mathematics, 2000). Therefore, though which one of the two constructs precedes the other or to what extent one influences the other is not yet clear (Smith, 2010), both should be recognized as fundamental bases for proper start in learning mathematics.

Moreover, counting per se is particularly important for later mathematics in which counting is used in early calculation (Geary, 2004). Counting can be further partitioned into separate but related components that are procedural versus conceptual. LeFevre (2006) shows originally that there is a strong correlation of both conceptual and procedural counting to mathematics, but little studies compare the impact of various types of counting, or evaluate their impact against other domain specific and domain general predictors.

Procedural counting: Koponen et al.(2007) defined procedural counting as the ability to correctly sequence numbers orally without reference to external visual stimuli. The trajectories of mathematical competence on a composite including basic arithmetic, knowledge of numbers, and word problems in preschool to grade 2 are found that oral counting ability predicted both initial performance as well as growth (Aunola et al., 2004). The predictive role of procedural counting are also documented in other studies (Koponen et al., 2007).

Conceptual counting, in contrast to procedural counting, conceptual counting refers to the child's *understanding* of counting procedures; that is, knowledge of principles that govern how and why counting works. As described aforementioned, Gelman and Galistel (1978) list five principles, for example three essential (one-to one correspondence, stable order, and cardinality) and two non-essential (abstraction and order irrelevance) counting principles. It is studied that whether or not mastery of the principle is required for correct counting (Kamawar et al., 2010).

Furthermore, early numerical competencies contents are discussed by Powell and Fuches (2012), mentioning basic counting, number recognition, understanding of symbols, quantity discrimination, and concepts of addition and subtraction. Then prior to moving onto more complex mathematical tasks, students should ascertain and understand these competencies. Each is discussed as follows,

Counting, students areless to counting and more to reciting, "1, 2, 3, 4, 5….". This means that students may face difficulties on the numbers representation, and they can often count to 10 (Bermejo et al., 2004). Based on the five counting principles as mentioned before, students can struggle with one or more of these principles (Bruce & Threlfall, 2004). Through combining stable order and one-to-one correspondence, the cardinality principle can be started to count sets of objects to determine the number in the set, for example, when counting a set of items, the final count, for instance, "4" after counting four objects, represents the set. Many students count from left to right and top to bottom because that is how they read in English, so it may be confusing to these students that counting does not have to occur in a linear fashion. To subitilizing, moving from counting items one by one is needed (Bruce & Threlfall, 2004; Hannula et al., 2007). Subitizing is the ability to instantly recognize how many items are in a group. Students should be able to look at each of the examples and instantly recognize that there are four boxes, three circles, one hexagon, and six squares.

Appreciating Quantity, children's appreciation of quantity is **s**ubitizing. Quantity discrimination, magnitude, or comparing numbers are used interchangeably with appreciating quantity. On the most basic level, students look at two numbers (e.g., 4 and 9) and answer the question, “Which is more?” (9) or “Which is less?” (4). It is possible to utilize manipulatives or pictures to aid in discriminating between the two quantities. In comparison with peers without MD, students with MD often encounter challenges with comparing numbers and less perform on comparing tasks (De Smedt & Gilmore, 2011). However, students may achieve better on quantity discrimination tasks that involve manipulatives and pictures but the number symbols (Rousselle & Noel, 2007).

Number and symbol recognition, this is the association betweencounts (e.g., one, two, three) with the number symbols (e.g., 1, 2, 3). Mathematical symbols are important because most of mathematics is represented using symbols. In order to represent any number you have, the consecutive ten number symbols (i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9) can be used alone or together with the other numbers. Besides the ten number symbols, early elementary students learn two operation symbols: the plus sign (+) for addition and the minus sign (-) for subtraction. Students also use the equal sign (=) in number sentences. Students might also use the inequality symbols for greater than (>) and less than (<) when comparing amounts. Students usually learn the

The operations of the plus and minus signs are understood by multitude number of students, however, little students exhibit difficulties to correctly interpret the equal sign and the inequality symbols (Hattikudur & Alibali, 2010). The inequality symbols (< and >) should also be understood as relational, with one side of the symbol representing a larger or smaller quantity. With appropriate instruction and practice, by comparison, students, even those who struggle with mathematics learn to interpret the equal sign relationally (Powell & Fuchs, 2010). However, students continue to misuse or misinterpret symbols well into higher grades without adequate instruction and practice (Verikios & Farmaki, 2010).

Addition and Subtraction Concepts, children can often solve simple addition and subtraction problems presented without symbols (i.e., presented orally and/or solved with manipulatives or counting; Sherman & Bisanz, 2009). Adequate counting, comparing, and symbol knowledge skills, however, are necessary to carry out most addition and subtraction problems presented to students in early elementary school. Baroody et al.(2009) indicate counting skills are important in solving addition and subtraction number combinations. Most of the time, young students use counting by ones as their default counting mechanism..

As indicated by Baroody et al. (2009), by the end of first grade, typically, students should know all 100 addition and 100 subtraction number combinations. But, children at the end of grade 1 in the Dutch regular education system (6-7 years old), these children are supposed to be able to correctly solve all additions and subtractions up to 20, and they are at the stage of practicing to become fluent (van der Ven. 2017). When starting addition and subtraction, students exhibited success solving addition problem than subtraction (Shinskey et al., 2009). This is on account of students learn counting forward well before they succeed in counting backward. Generally, the addition skills of students are stronger than their subtraction skills, even students who are struggling with mathematics. Torbeyns et al. (2009) indicate multitude number of students solve subtraction problems more efficiently when they use addition skills. According to Gilmore and Papadatou-Pastou (2009), those students who acquire a good understanding of the relationship between addition and subtraction exhibit better conceptual knowledge and better subtraction performance than those students who do not acquire a good understanding of this relationship.

To guide the assessment and the instructional strategies for children in early primary school, MoE of Ethiopia (2008) developed numbers and operations related to National Minimum Learning Competencies /MLC/ in Mathematics from grades 1 to 4. For this dissertation purpose only grade one is opted. The areas of competency of grade one is listed as follows

Numbers : whole number

- Read and write natural numbers up to 9.
- Order natural numbers up to 9.
- Use the symbols "<", ">" and "=" to compare natural numbers up to 9
- Recognize the number zero and write the symbol for zero ―0‖
- Read, write and order whole numbers up to 20.
- Apply place value to numbers up to 20
- Count in 10s up to100
- Read, write and order whole numbers up to 100
- Compare whole numbers up to 100 using the symbols "□","<" and "="
- Identify place value in tens and units

Number: fractions

- Divide a concrete object into two equal parts and show understanding of the term a half
- Divide objects into four equal parts and show understanding of the terms quarter and three quarters
- Divide a concrete object into two equal parts and show understanding of the term a half
- Divide objects into four equal parts and show understanding of the terms quarter and three quarters

Operations:. addition

- Add three natural numbers up to 9.
- Add three numbers whose sum is not more than 9.
- Add up to 20
- Add multiples of 10 whose sums are less than 100.

Operation: subtraction

- Subtract multiples of 10 which are less than 100.
- Solve problems of addition and subtraction on whole numbers up to 20

Operation: multiplication

- Multiply whole numbers up to 10 by 2 and identify the symbol "x " for multiplication

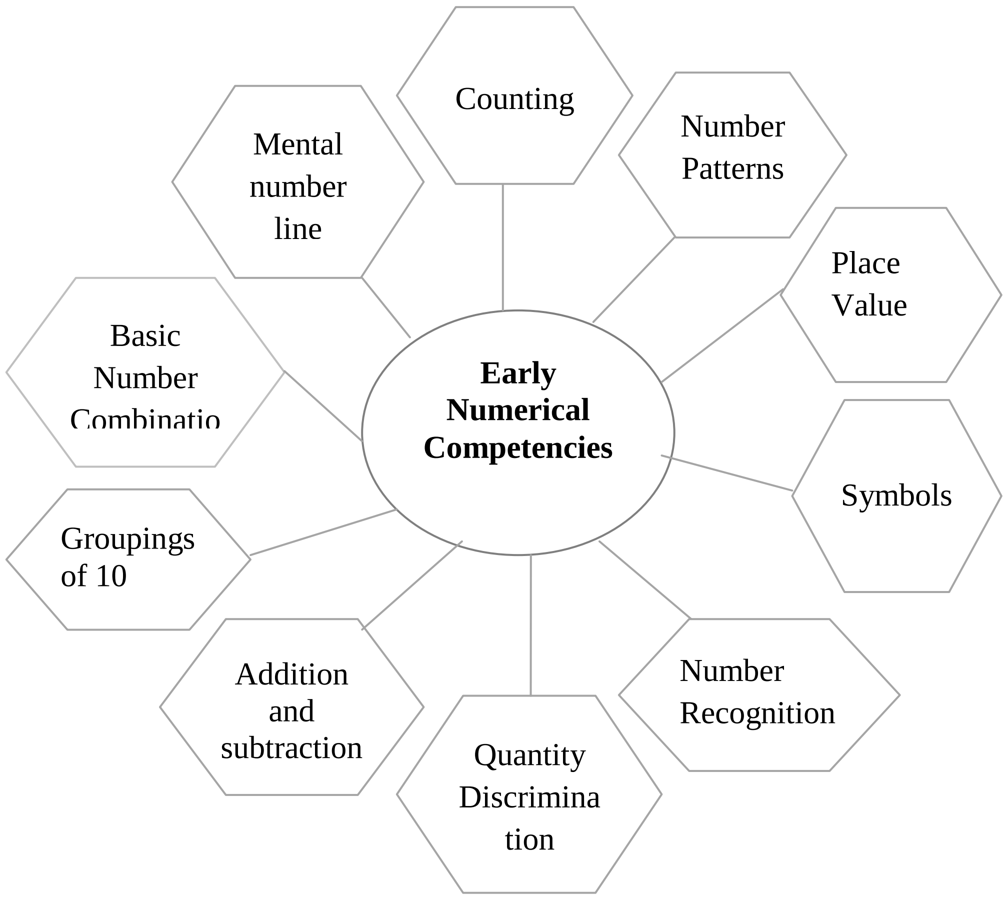
Operation: division

- Divide whole numbers up to 20 by 2
- Identify the symbols "÷ ":for division

To wrap up, the aforementioned points have similar intention in terms of the early instructional contents. They comprise common early number competences contents like powell and Fuches (2012), see Figure 4. The contents in general focused on the list of foundational skills and concepts in mathematics learning. The term foundational is not used to indicate that number learning starts in schools but to emphasize on the initial school-based experiences of children and the start of learning numbers (the basis of mathematics) in a formal environment. These foundational concepts and skills can be categorized into two main constructs: *CNC, and* *arithmetic*. That is, each of these constructs encompasses differing lists of skills or principles (Smith, 2010) from which those applicable to this research were selected.

Figure 4

Early Numerical Competencies (Taken from Powell and Fuches (2012))



2.8.Mathematics Difficulties: Gender, Types of LD, and Prior Mathematics Knowledge

2.8.1. Gender

From a wider picture, the term "gender" refers to a socio-cultural classification of women and men (Devine et al., 2013). The report of the gender ratio of MD in past studies has not been invariant. For instance, the study of Dirks et al. (2008) show the prevalence of MD using the Dutch standardized tests favored slightly for girls than boys in Grade 4 and 5, using performance below the 25^{th} or 10^{th} percentile. Heedless of the age of children and the definition of MD, Barbaresi et al. (2005), in the contrary, explicated that collective that incidence of MD favored boys than girls. Besides, in young children (kindergarten to second grade), as per Mazzocco and Myers (2003), there was an incident of MD for girls and boys. Similarly, other studies found that the prevalence of MD favored equally for girls and boys in older elementary school children (Koumoula et al., 2004).It is stressed that the gender ratio depended on the diagnosis of MD using a diagnostic test (prevalence favors boys than girls), teachers identification (prevalence favors girls) or using exclusionary criteria (equal prevalence) (Ramaa & Gowramma, 2002). Thus, the gender ratio does not systematically relate to the age of the sample or DD definition used, across the different studies.

With respect to mathematics achievement, gender differences of MD and math competency have been extensively studied. The results are inconsistent, classic studies have shown an advantage for boys in overall mathematics attainment (Benbow & Stanley, 1980). Stereotypically, according to Ashcraft (2002), when they take math exam women score less than men. But, recently, no gender differences emerged for mathematics performance (Devine et al, 2012). The plausible reasons for the gender gap in mathematics can be developmental factors such as social roles, social expectancies, attribution, motivation, problem-solving strategies, and self-confidence (Birenbaum & Nasser, 2006; Timmermans et al., 2007).

As far as motivation concerned, according to Guay et al. (2010), the effects of gender on motivational components were observed in this study. Girls, in reading and writing, are more intrinsically motivated than boys. Besides, they are more regulated by identification towards writing than boys. In contrast, boys are more intrinsically motivated towards maths than girls. These results parallel those of other studies (Eccles et al., 1993), and indicate that gender stereotypes may affect motivation processes in the early grades.

It is not specific to the present study. The effect of game-based learning was investigated in regards to gender. Musselman (2014) indicated that the preference of active game mode followed by strategic game mode favored boys than girls; whereas girls preferred creative game mode followed by explorative game mode. There is no preference difference between genders in terms of problem-solving and social game modes. Heedless of gender, Kinzie and Joseph (2008) encourage the use of explorative and problem-solving games, since they appealed to both genders equally. On the study of Kim and Chang (2010), they investigated the effect of game-based learning in regards to gender, showing that the math achievement for boys had a direct correlation with an increased computer game use in the math, but it does not work for girls.

Furthermore, the research on the effect of game-based learning and gender, Robertson (2012) explored the game creation skills of students with respect to game design and storytelling, showing that girls performed better in creating their video games. Roberton added boys may be better than girls in the enhancement of storytelling skills through their interest in gaming technology. Conversely, girls may be motivated with technology for the sake of their enjoyment of storytelling (Robertson, 2012). Additionally, Chen et al.(2019) indicated that videogames had potential educational value, 39% for female subjects, and 31% of male subjects. There remain many criticisms of game-based digital learning, such as that they have the potential to cause addiction, violence, and other negative effects (Lin, 2012). In addition, many studies have also found that the effectiveness of game-based digital learning varies, unlike traditional teaching or digital learning; thus, the results of game-based learning can be uncertain.

2.8.2. Difficulty Type

Students with MD demonstrate varying levels of reading performance (Powell & Fuchs, 2009). The hypothesis suggests that students who struggle with MDRD exhibited weak phonological processing skills (Robinson et al., 2002). Deficits in phonological processing hinder acquisition of vocabulary and math facts, therefore leading to MDRD. On the contrary, a weak number sense was exhibited by students with MD alone (i.e., MD-only), which leads to poor recall of math facts (Robinson et al., 2002). Specifically, a related literature focuses on fact retrieval deficits associated with these MD subtypes. Hanich et al. (2001) administered tests of arithmetic calculation. It is clear that MD-only students can perform above the 40th percentile in reading but below the 35^{th} percentile in math. However, the performance of MDRD students is below the 35^{th} percentile for both math and reading. The comparison performance on untimed arithmetic calculations, the performance favored significantly for MD-only students than MDRD students, but students in the control group performed better than MD-only students. A comparable performance was registered for MDRD and MD-only students on timed retrieval of number facts. But, they performed significantly below control students.

Moreover, Anderson and Lyxell (2007) found on arithmetic that in comparison with average-performing peers only students with MD answered as many number combinations correctly, this happens when students gained more than 3 seconds to respond. Without putting into consideration of the provision of time, MDRD students did not solve as many problems correctly. Contrary to Andersson and Lyxell (2007), Hanich et al. (2001), and Jordan and Montani (1997), there were no differences between MD subtypes on the untimed task. Micallef and Prior (2004) found that there were no detection of MD subtype differences on basic facts. They carried out study on 7–14 years old. MD-only and MDRD students on problem solving tasks. Then in comparison with their counter parts peers, MD-only and MDRD students performed significantly worse and took longer to solve problems. To solve the math facts, both MD-only and MDRD students used a greater variety of strategies, but the strategies were less reliable than those utilized by control students.

Power et al.(2011) reviewedfour studies; looking through performance differences between MDRD and MD-only students. Previous researches on the performance differences on number combinations show the outperformance of MD-only students in comparison with MDRD students (Hanich et al., 2001) , however, there was no demonstration of differences between students with MDRD and MD-only on number combinations (Geary et al.,1999). Yet, some patterns in the data provide the basis for hypothesizing that relative to students with MD only, students with MDRD may require more intensive intervention, and different kinds of intervention, that have more systematic practice with a greater emphasis on language. Large scale intervention research is, however, needed—with adequately large samples of students with MD with and without reading difficulties to assess the tenability of these hypotheses.

To recap, Geary et al.(2000) indicate the similar performance in simple counting tasks between the MD subtype, MDRD and MD only students. However, Geary et al. (2000) and Jordan & Hanich (2000) showed that in comparison with MDRD, MD-only students use more efficient counting procedures on arithmetic problems. Additionally, untimed fact retrieval tasks favor MD-only students than MDRD students (Andersson & Lyxell, 2007; Hanich et al., 2001), however, on timed fact retrieval tasks both groups of students perform similarly. By contrast, Micallef and Prior (2004) indicated that both MD-only and MDRD students perform a similar faction on fact retrieval tasks, without making time as a factor.

The study of Bryant et al.(2011) examines (a) mathematical skills of 2 subgroups of children with developmental dyscalculia (DD), one group with DD only and a second group with DD plus reading disorders (RDD, and (b) the memory skills of both groups of children. Results indicated that children with DD and children with RDD show a similar pattern of mathematical impairment. Both subgroups had significantly lower scores than the control group in working memory tasks. In addition, the RDD group had significantly lower scores than the control group in visual learning and semantic memory. Although the RDD group scored lower than the DD group in most memory tests, this difference did not reach significance. Working memory tests (digits backwards and sentence repetition) appeared to be the best predictors of mathematical test scores and may represent a major cognitive defect in children MD.

2.8.3. Prior Mathematics Knowledge

As toRajkumar and Hema (2017), a student's prior knowledge and previous experiences with mathematics are the best predictors of future success. Many of these experiences have been influenced by the factors described above. However, previous instructional experiences also can have a significant impact on achievement. If previous teachers did not explain concepts well, use effective teaching methods, or allow time for mastery and success, students' mathematics learning will be affected. If the curriculum and materials used weren't aligned with math standards, learning might be superficial or limited. And if the student wasn't able to develop the deep concept understanding that comes from good teaching and sound curriculum, his or her math achievement will suffer. The findings indicated that prior mathematics knowledge did not play a significant role in achievement and motivation of the participants who played the games.

2.9.Mathematics Difficulties: Mathematics Achievement and Motivation

2.9.1. Learning achievement

It is the evaluation of students at the end of the completion of certain learning activity and the achievement of learning activity to expected effect (Camp, 2012). In another way, Lederer and Battaglia (2015) indicated that learners would change the knowledge, skills and behaviors, and attitudes after the instruction. A major measuring indicator of learning achievement as well as a major item to evaluate teaching quality is students' learning outcome (Bornstein & Bruner, 2014). The indicator to evaluate students' learning outcome is a major item to evaluate teaching quality, learning achievement would be affected by course design, teaching approach, and learning behavior, and student learning aims to monitor self-learning, retrospect the learned knowledge, and learn how to learn (Erhel & Jamet, 2013). Consequently, learning achievement would be highly related to the presentation of learning outcome. At this point, this dissertation paper focuses specifically to review the mathematics achievement of students with MD in counting, addition and subtraction as well as the relationship among these three outcome variables. Counting plays a significant role for later mathematics achievement (Carrasumada et al. 2006), in part due to its explicit role in the transition to formal arithmetic in which counting is used in early calculation (Geary, 2004). Besides, LeFevre et al. (2006) and Stock et al. (2009) pointed out that specific components of conceptual counting are related to mathematical outcomes at young ages. Stock et al. (2009) indicated that stable order, one-to-one correspondence, and cardinality of pertinent counting principles such as in kindergarten predicted grade 1 arithmetic (14% variance) and math facts (5% variance). Besides, Praet et al. (2013) found procedural counting to be more predictive than conceptual counting of a composite grade 1 math outcome from kindergarten to grade 1, within the context of language variables and a square estimation/ counting task. However, both procedural and conceptual counting are not unique predictors for generalized language, logical thinking, the square task, and a non-symbolic comparison task.

With respect to relation between addition and subtraction, Shinskey et al.(2009) revealed that in early arithmetic, students often solve addition problems more successfully than subtraction problems. This is due to the fact that students acquire the skill of counting forward well before they succeed in counting backward. In comparison with subtraction skills, the addition skills of students with or without MD are generally stronger, and more efficient (Torbeyns et al., 2009). As per Gilmore and Papadatou-Pastou (2009), students who understand the relationship that addition is the inverse of subtraction and vice versa demonstrates better conceptual knowledge and better subtraction performance than students who do not understand this relationship. As children develop understanding of the relationship between subtraction and addition (Baroody, 1999), knowledge of addition number concepts facilitates knowledge of subtraction number concepts.

2.9.2. Mathematics Motivation

There are various definitions of motivation as a body and learning motivation in specific. Learning motivation is a kind of motivation, at which, Lai (2010) regarded learning motivation as the inherent belief to guide individual learning goals, induce learning behavior for continuous efforts, reinforce cognitive processes, and enhance and improve learning outcomes.Motivation is explicated under SDT, applied to education, it refers to the reasons that students engage in different school activities (Ryan & Deci, 2000). Different types of motivation are distinguished under SDT, which vary in terms of self-determination. Intrinsic motivation refers to engaging in an activity for its own sake, for the pleasure and satisfaction derived from participating in it (Huang et al., 2013; Cheng et al., 2013). Extrinsic motivation refers to engaging in an activity for instrumental reasons rather than for the intrinsic qualities of the activity. From low to high self-determination, Ryan and Deci (2000) indicated there are different types of extrinsic motivation, viz., external regulation, introjected regulation, identified regulation, and integrated regulation.

- External regulation, in this case, behaviour is motivated for the sake of obtaining a desired reward or avoiding punishment.
- Introjected regulation refers to behaviours motivated in response to internal pressures such as obligation or guilt: the individual somewhat endorses the reasons for doing something, but in a controlled way.
- Identified regulation occurs when individuals identify with the reasons for performing a behaviour, or when they personally find it important. This is a self-determined form of extrinsic motivation, because the behavior originates from the self in a non-contingent way.
- Integrated regulation occurs when the identified regulation is congruent with other values and needs. The behavior is, therefore, performed because it is part of who the person is. These types of motivation have been associated with school outcomes. For example, students who endorse autonomous types of motivation (intrinsic and identified regulation) are more persistent and cognitively involved in their tasks, experience more positive emotions and have better grades, whereas students who are motivated in a controlled fashion are less persistent, more distracted, experience more negative emotions (anxiety), and obtain lower grades (Guay et al., 2008). These findings underscore the importance of developing autonomous motivations (intrinsic, identified) in contrast to controlled motivation during the early school years.

In general, introjected and external regulation are assessed jointly under the construct of controlled regulation (Shahar et al., 2003) in order to reduce the number of items for which young children would have to provide responses. According to SDT, motivation types can be ordered along a self-determination continuum. Motivation types are therefore expected to relate to each other in a simplex like pattern, with stronger positive correlations between adjacent than distant motivations. For example, identified regulation and intrinsic motivation should be positively and moderately correlated, and this correlation should be higher than the correlation between intrinsic motivation and controlled regulation. Previous research has supported the self-determination continuum for motivation types towards school in general (Otis et al., 2005). The dissertation focuses on motivation types towards specific school subjects, in this case mathematics, where it is expected the self-determination continuum to be replicated in school subject.

Educational researchers and practitioners recognize that school motivation is vital for academic achievement and persistence (Pintrich, 2003). This has opened the way to a recent series of intervention programmes specifically designed to improve student motivation at school (Wigfield & Wentzel, 2007). When examining the role of student motivation, we may consider it as either a general construct (i.e., student motivation towards school in general) or specific to school subjects (e.g., student motivation towards maths). These two ways are pretty significant to put into consideration of the understanding general as well as specific academic outcomes (Elliot, 2005; Green et al., 2007; Pintrich, 2003). Here, Guay et al.(2010) focus on specific school motivations. There are two approaches to the differential examination of school motivation. The first is to examine motivation towards specific school subjects. This has been done from several theoretical standpoints (e.g., goal theory, self-efficacy theory, self-concept, and the expectancy-value model), and has focused primarily on disciplines such as writing, reading, and maths. These theories refer to motivational differentiation as between school subject differentiation. On the other hand, school motivation can be considered as another approach of a multidimensional concept that varies in terms of both intensity and quality. An example of this approach is indicated by Ryan and Deci (2002) of self-determination theory (SDT) that differentiates among types of motivation. This motivational differentiation can be considered as within school subject differentiation. The within and between school subjects are the two differentiation types of motivation have played a role for discoveries and a better conception of student motivational dynamics and the associated outcomes. However, little research has combined these two approaches. In addition, they examine whether these differentiations vary across age groups. For example, are older children better able than younger children to differentiate types of motivation for a given school subject (within school subject differentiation) and a given motivational construct across school subjects (between school subject differentiation)? It is important to find the answer to this question, because it may inform us on how motivation develops during formative years that are important for later school adjustment.

As proposed by Bakar and Nosratirad (2013), ability belief, success expectancy, and work value are important variables of learning motivation in student' self-learning regulation process. Ability belief refers to students perceiving personal ability when engaging in learning. Success expectancy refers to students' expectation of success during learning. Such expectation is efficacy expectation, rather than outcome expectancies, i.e. learners' perceived learning performance and selection, rather than the expectation of results. Work value contains important achievement value to do tasks well, intrinsic value to enjoy the harvest of doing something, practical value of tasks conforming to personal future plans, cost of devoting to an activity but restricting to approach another activity, and interests in learning. Learning motivation is an intervening variable between stimulus and response. That is, learning motivation is personal opinions about affairs and learners would appear to have different knowledge needs because of distinct opinions. Call et al. (2012) revealed that learning motivation was the intrinsic psychological process to induce students' learning activity, maintain the learning activity, and have the learning activity approach the goal set by teachers so as to achieve the teaching goal; and, the teachers could precede effective teaching.

In various causes, students in mathematics classrooms often exhibited the feeling of unmotivated on account of mundane, repetitive and the boring nature of teaching methods which is manifested in primary school mathematics classrooms. Meanwhile, pupils go through the education system, teachers and administrators need to be concerned with pupils that appear to be motivated and have below grade level abilities. Especially for those students who have often exhibited successive mathematics failure in the earlier grades. If so, according to Banda et al. (2009), improving students' motivation is a complex and ongoing process. There is a need that school experts to investigate methods to enhance pupils' motivation and help pupils to be successful in school. Eventually, Dennis and Stockall (2015) pointed out motivation as the requirement for long-term, effective, and meaningful learning.

2.9.3. Relation between Achievement and Motivation

The relation between achievement and motivation are studied in various ways. Lepper et al. (2005) investigated two motivational orientations, intrinsic and extrinsic motivation, allowed for an examination of the achievement outcomes associated . In both class and on standardized tests, they figured out that there was a positive relationship between intrinsic motivation and performance. This is because as intrinsic motivation theorists have long argued, being interested and engaged in the process of education results in better learning and achievement (Cordova & Lepper, 1996). Perhaps more interesting is the negative relationship between both indices of performance and extrinsic motivation, which was seen for both the composite measure and the individual subscales, with the exception of the subscale assessing dependence on the teacher. That is, to the extent that children reported a desire for easy work and an aim to please their teachers, they performed worse both on standardized tests and in regular classroom assessments (Ginsburg & Bronstein, 1993). This demonstration of the adaptive value of intrinsic motivation relative to extrinsic motivation is particularly informative in light of recent debates about the impact of tangible rewards and other forms of extrinsic motivation on intrinsic interest and creativity (Eisenberger et al., 1999). Of course, these are only correlational findings, and it is unclear whether it is the type of motivation that drives achievement, the level of achievement that drives the type of motivation, or some combination of the two. It is certainly plausible that children who do well in school might come to enjoy learning, feel capable of taking on challenges, and like to master the material independently as a result of receiving high marks and positive feedback. It is also possible that children who do poorly in school are more often subjected to lectures from teachers and parents about how and why they should be doing better, thus shifting their attention to more external sources of motivation. At least some evidence, however, suggests that democratic parenting practices are positively correlated with academic achievement even when controlling for previous academic achievement (Steinberg et al., 1992).

2.10. Mathematics Difficulties: Mathematics Education in Ethiopia

Mathematics is an instrument that helps students to get the knowledge and experience about life, learn how to deal with problems, apply their knowledge to real-life situation, improve their ability, about logical thinking and reasoning, and they are getting ready for their future (Arslan, Çanli, & Sabo, 2012). Moreover, it is a useful device whereby students actively acquire knowledge through problem-solving in relation to the challenges faced in their day-to-day lives. In Ethiopia, as a result, the mathematics subject is offered separately from pre-primary through tertiary education and passed through various history time of mathematics education. Hailu (2016) indicates that the religious sector or the indigenous people settled in rural areas were the foundation of the early history of mathematics education in Ethiopia. That is, on account of the outcome of the societal experiences, people of Ethiopia had a perfect calendar different from the westerns, astronomical knowledge, early artifacts, ideas of probability, mathematical board games (gabat’a), mathematical sayings, and designs that comprise geometric, algebra, or a combination of both and patterns of interest. In all parts of the globe, mathematical thoughts and practices originated from people's real desires and interests in all cultures (Zaslavsky, 1993).

According to Bush (2005), like many nations around the world, the modern history of mathematics education in Ethiopia was more or less associated to curriculum materials from other countries cultures. Owning to the changing and competitive world or foreign political influences, educational and cultural effects from other countries, Ethiopia has undergone many curriculum changes in mathematics education over the past 10 decades. For instance, right after the end of the Italian invasion in the early 1930s, the Ethiopian government established a political relationship with the British government and adopted the mathematics curriculum from Britain that entails two series known as Durell and Hudson and High Way Mathematics Series (Behute, 1991). Because of the drawbacks, in 1967, “The Entebbe Mathematics Program” was introduced in 10 African countries, Ethiopia, Ghana, Kenya, Liberia, Malawi, Nigeria, Sierra Leone, Tanzania, Uganda, and Zambia (Woodhouse, 1973). This mathematics program was initiated and developed by Mathematicians/experts from the US, which continued until the early 1990s. In 1994, the issue of learner-centered education boldly arisen in the Ethiopian Education and Training Policy (MOE, 1994). Moreover, the policy document acknowledged the ethnic diversities in the country and declared their rights to learn in their mother languages. However, still, mathematics education contents remained westerns focused, as Moreira (2007) referred it as mathematics from the “outside world”. In this regard, Izmrili (2011) indicated, many Ethiopian textbook authors and curriculum experts reflected and promoted much of the Western Mathematics, which led to the erroneous interpretation of the history of mathematics merely as a progressive story of the isolated successes of the chosen few societies. Nevertheless, numerous researchers (Matang, 2002; Bush, 2005; Rosa & Orey, 2010), indicated as each society has something to contribute to the improvement of mathematics education and has the potential of mathematizing in its own culture at any cost. Therefore, although, the concept of mathematics is almost similar worldwide, it is crucial to adapt to the country’s specific contexts during curriculum reform, design, and development.

It is known that Mathematics achievement in almost all Ethiopian schools is very low but this problem has never been associated with the problem of mathematical learning disability. There is general consensus among professionals in the field that mathematical disability is widespread in young children and that it has serious educational consequences (Bryant, 2000; Jordan & Hanich, 2000). MoE of Ethiopia (2008) developed numbers and operations related to National Minimum Learning Competencies /MLC/ in Mathematics from grades 1 to 4, to guide the assessment and the instructional strategies for children in early primary school. Currently, mathematical disability is an academic discourse and considered as one reason for the low achievement of students and some researches has begun to be done in that area.

In general, based on the objectives of this dissertation work, the literature review from various experimental and theoretical sources comprises enormous points that lead to flow in the path from identification to all aspects of intervention. Review of the methodological aspects are not portrayed in this section. It is, nonetheless, put in use in the methodology sections. The researcher believed that this review shapes the design of the experiment, the intervention strategies, conceptual frame work and etc.

Chapter Three

Methodology

3.1. Research Paradigm

In order to decide which methodologies stance are useful for studies are determined partly by their ontological and epistemological perspectives (Mustafa, 2011). These ontological and epistemological perspectives are situated within a positivist worldview, and they are compatible with the current study on the effect of instructional intervention on the achievement and motivation of students with MD. This is for the reason that, the positivist paradigm was the most dominant paradigm that influenced educational research for a long period (Grix, 2010). Besides, it is mostly explained by its epistemology is said to be objectivist, its ontology naive realism, its methodology experimental or non-experimental, and its axiology beneficence. The objectivist epistemology holds that human understanding is gained through research we can acquire knowledge which increasingly approximates the real nature of what it is investigated (Fadhel, 2002).The naïve realist ontology assumes the acceptance of beliefs by means of our senses, we perceive the world directly, and pretty much as it is (Putnam, 2012; Searle, 2015). Experimental and non-experimental methodology (descriptive, comparative, correlational, or causal comparative) are quantitative methodology (McMillan, 2000). Experimental methodology involves experimental (or treatment) and control groups and administration of pre- and post-tests to measure gain scores (Taylor & Medina , 2011). The beneficence axiology refers to the requirement that all research should aim at maximizing good outcomes for the research project, for humanity in general, and for the research participants (Martens, 2015).

Specifically, explicating in terms of the current study by unpacking each of these research paradigm elements, the epistemology is manifested by the pretest–posttest control group design that utilize treatment, outcome measures and experimental units, and use random assignment to create control group from which treatment caused change is inferred. The quality standards of this paradigm are *objectivity*, *validity* and *reliability*. Apparently, students with MD are benefited for this study specifically, but humanity in general.

In the contrary, Regehr (2010) argued that the problem with experimental design in educational research is therefore not only the impossibility to create controlled, non-complex educational environments that enable determining the value of the effect of an instructional intervention, but also the impossibility of randomization to control for other sources of variation and confounding factors that are likely to be found in educational contexts to take up ontological and epistemological positions in a technical rationalist framework that perceives the world as having a single truth, which is inconsistent with a real understanding of learning. However, in line with this study, randomization in pretest-posttest control design and the presence of a control group and pretest served to control all threats to internal validity (Mills & Gay, 2019).

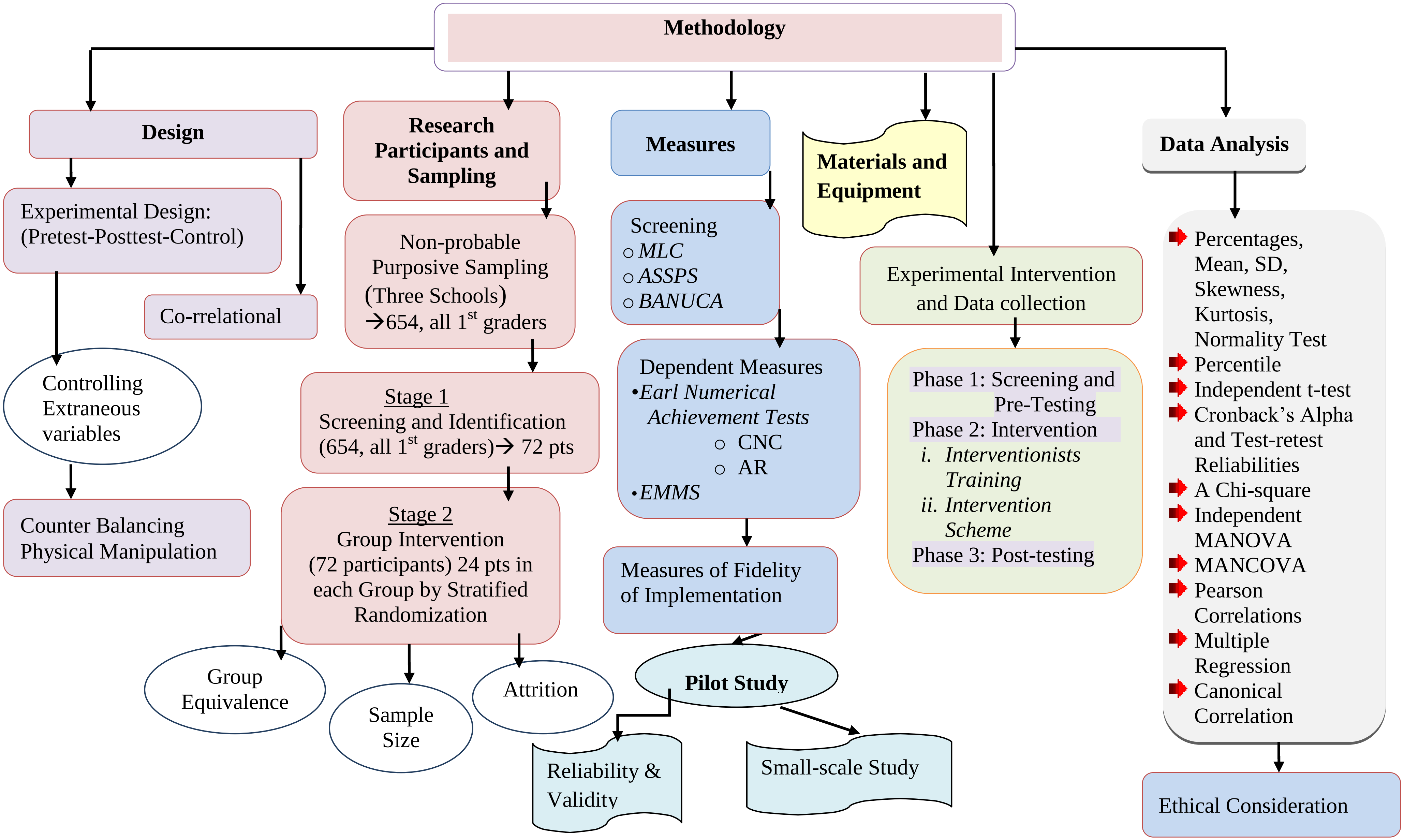
Eventually, this section discusses research design and approach, the sampling frame and sample size, sampling procedure, various measuring instruments, experimental research procedures, training of interventionists and assessors, instruments' reliabilities and validation, pilot study, data entry, and analysis techniques used in the process. For simplicity, to see the whole picture of methodology, the methodological glance is portrayed in Figure 5.

3.2.The design

The data on CNC achievement, arithmetic achievement, and early mathematics motivation (EMM) were analyzed using four independent variables, such as instructional approaches, gender, prior mathematics knowledge, and difficulty status; whereas the two dependent variables are early numerical achievement and early mathematics motivation score. The quantitative study was employed, in due focus on experimental research having experimental and control groups. The effects of early numerical instructional intervention in CNC and arithmetic were assessed using pretest–posttest control group experimental design with some descriptive survey. The pretest–posttest control group is a true experiment since randomization was enacted. The design, implicitly, indicates the intervention tests are the stages in the design, it took 18 weeks to carry out the intervention for both, CNC and arithmetic. Based upon this experimental design, the experimental time-line, the intervention contents and the prominent variables were unfolded in the following ways for CNC (see Table 1) and arithmetic (see Table 2).

Figure 5

Methodology at Glance



In Table 1, the design with an experimental group and a control group was employed using concrete fading instruction with gabat'a (as IV) on the enhancement of CNC achievement and early mathematics motivation (as DVs) in a group of primary school children with MD. The dependent measures of DVs were taken at pre and post programme, having 10 weeks gap between them. The two interventional conditions as IV were CIGO, and control group (CG). CIGO is applied by rendering CRA instruction using gabat'a as an instruction aids without the game. CG is enacted when students with MD neither received the instruction using gabat'a nor utilizing as a gabat'a game but they received a regular instruction.

Table 1

The Experimental Design, the Experimental Time-line, and CNC as the Dependent Measures

Groups	Pre-test	10 weeks ⟷	Post-test
Experimental group (CIGO)	n=36	Instruction using *gabat'a* without game	n=35
Control group (CG)	n=36	Business as usual instruction	n=36
	DV CNC measures EMM scale		DV CNC measures EMM scale

In Table 2, with two experimental groups and a control group by enacting randomization, it is possible to evaluate the impact of early concrete fading arithmetic intervention using gabat'a (as IV) on arithmetic achievement and early mathematics motivation (as DVs) in a group of children with MD. The design, implicitly, indicates the intervention program and tests (pre- and post-test) are the stages in the design. The intervention was taken place for 8 weeks. The three arithmetic interventional conditions as IV were AIGG, AIGO, and CG. AIGG refers to the interventionist providing arithmetic instruction using gabat'a as instructional aides and a game. AIGO is applied by rendering arithmetic instruction using gabat'a as an instruction aids without the game. CG is enacted when students with MD neither received the arithmetic instruction using gabat'a nor utilizing as a gabat'a game but they received a regular instruction.

Table 2

The Experimental Design, the Experimental Time-line, Arithmetic as the Dependent Measures

Groups	Pre-test	8 weeks ⟷	Post-test
Experimental group one	n=24	Instruction with *gabat'a* plus *gabat'a* game	n=24
Experimental group two	n=24	Instruction using *gabat'a* without game	n=23
Control group	n=24	Business as usual instruction	n=24
	DV		DV
Arithmetic (ADD and SUB) measures EMM scale		Arithmetic (ADD and SUB) measures EMM scale	

Moreover, in order to examine the relations among variables (CNC, arithmetic and early mathematics motivation), a co-rrelational research design was employed. Co-rrelational designs can be applied when researchers try to make inferences and investigate the possible relations between or among variables (Gall et al., 2007). The design plays a role helping to clarify relations among variables and showing future directions for experimental research (Schunk et al., 2014). According to Thompson et al. (2005), this non-experimental design is a proper design when the researchers utilize a non- randomized assignment of groups. The recent studies show that it is possible to have a correlational design for randomized participant in repeated experimental study (Srinivas and Chakrabarti, 2017). As per Srinivas and Chakrabarti (2017), correlation analysis in repeated measures design has not been rigorously described till date. The potential and the correct method includes, separate simple regression /correlations, repeated measure correlation (rmcorr), and simple regression/correlation using averaged data. For this dissertation study, the last one was chosen since averaging the repeated measures data (pretest and posttest) for each participant prior to performing the correlation may resolve the issue of non-independence (Myung et al., 2000).

3.3.Variables

3.3.1. Independent variables

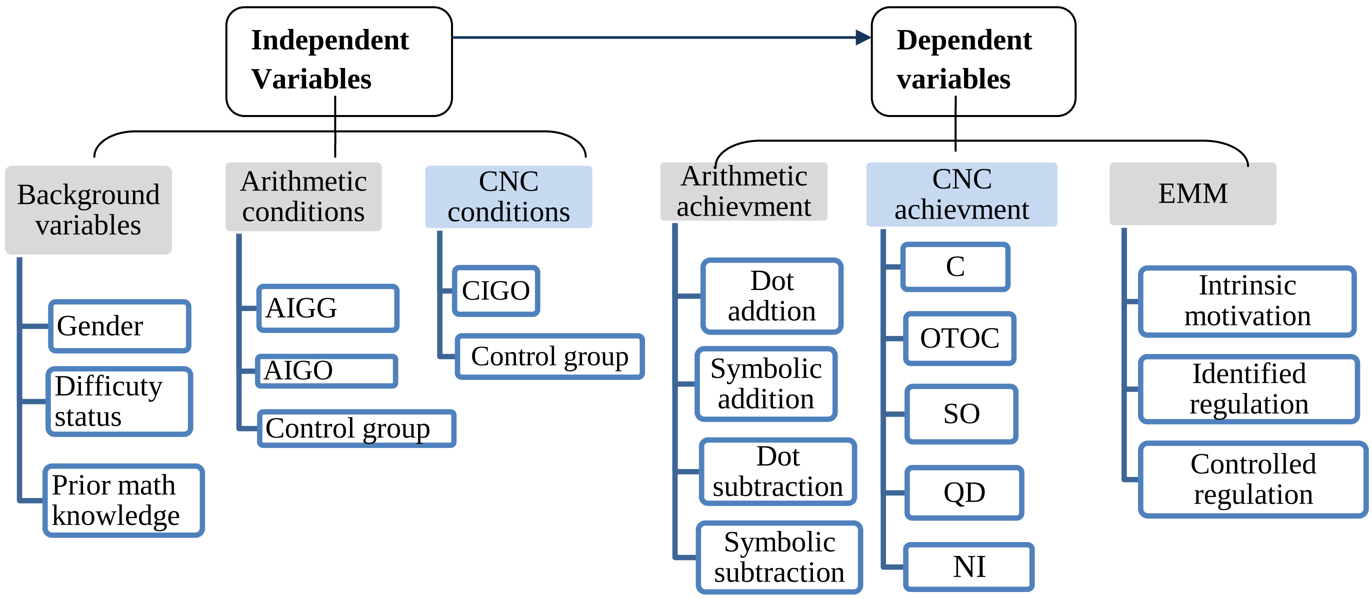
The independent variables in this study were background variables on three levels: gender (male and female), MD subtype (MD and MDRD) and prior mathematics knowledge (yes or no) and research conditions on two levels for CNC: CIGO and control group; and three levels for arthimetic: AIGG, AIGO and control group.

3.3.2. Dependent variables

In this study, three dependent variables were evaluated, including students' CNC and arithmetic achievement, and early mathematics motivation; these variables were measured by tests and scales as described in the measure section below, respectively. CNC comprises one-to-one correspondence (OTOC), cardinality(C), and stable order (SO), number identification (NI) and quantity discrimination(QD); and arithmetic achievement entails addition (dot and symbolic) and subtraction (dot and symbolic) where as early mathematics motivation (EMM) entails intrinsic motivation (IM), identified Regulation (IR) and, controlled Regulation (CR), see Figure 6.

Figure 6

Independent and Dependent Variable



3.3.3. Extraneous variables

In the present study, since the design is a pretest-posttest control group design and by its nature, randomization was conducted in which students were stratified according to their gender, prior knowledge, difficulty status; and then randomly assigned to a control and two interventions conditions. Randomization and the present of a control group and pretest served to control all threats to internal validity (Mills & Gay, 2019).Both instructional intervention protocols for remediating students with MD are evaluated against each other and against a non-intervention control group. By including a control group, it is pretty possible to control historical effects, testing and instrumentation; by incorporating two intervention conditions, it is possible to control for instructional time when considering the effects of one protocol against the other; random assignment controls for regression and selection factors; the pretest control for mortality; and randomization and the control group control for maturation since the experiments took place for 18 weeks in total, there might be maturational change in the side of the children's physical, social, emotional, and language skills. This phenomenon was controlled using the control group which was not exposed to the intervention program was already set.

The aforementioned traits were controlled through the design of the experiments. However, other variables required physical manipulation of the environment and counter balancing. To do so, a number of steps were taken to control some extraneous variables that constitute traits to the validity of the study. These variables include:

Teachers Variables. The level of the teachers' training was similar in terms of degree and experiences**.** The students' regular mathematics teachers were used to carry out the intervention using gabat'a as instructional aids and game. The teachers were involved in both the control and the experimental groups in a counter balancing way while the researcher does the supervision. The following Tables 3, 4 and 5 are the time-line for the counter balancing. A uniform standard in the content of the lesson was ensured with the researcher prepared lesson plans and clearly stated lesson objectives to reduce teacher effect.

Table 3
Teachers' Allocation for CNC Instruction

CNC instruction				
	Weeks			
Conditions	Week 1	Week 2	Week 3	Week 4
Experimental group	Teacher 1	Teacher 2	Teacher 2	Teacher 1
Control group	Teacher 2	Teacher 1	Teacher 1	Teacher 2

Table 4
Teachers' Allocation for Arithmetic Instruction: Addition

Arithmetic Instruction: Addition				
	Weeks			
Conditions	Week 1	Week 2	Week 3	Week 4
Experimental 1	Teacher 1	Teacher 3	Teacher 2	Teacher 3
Experimental 2	Teacher 2	Teacher 2	Teacher 3	Teacher 1
Control	Teacher 3	Teacher 1	Teacher 1	Teacher 2

Table 5
Teachers' Allocation for Arithmetic Instruction: Subtraction

Arithmetic Instruction: Subtraction				
	Weeks			
Conditions	Week 1	Week 2	Week 3	Week 4
Experimental 1	Teacher 1	Teacher 3	Teacher 2	Teacher 3
Experimental 2	Teacher 2	Teacher 2	Teacher 3	Teacher 1
Control	Teacher 3	Teacher 1	Teacher 1	Teacher 2

Inter-Group Contamination (Diffusion). Students in a particular sample school were subjected to the same treatment, either as control or as experiments. The case of having both the experimental and control groups in the same school was avoided to eliminate inter group contamination. This means that arranging a separate place for control was the ideal way of eliminating contamination. But, as it mentioned before, the experimental design utilized randomization. In the presence of randomization, it is pretty difficult to control diffusion. As a minimum controlling, the game materials (gabat'a and others) were not made available right after the lesson delivery. The two experiments underwent in School 1 and school 2 but School 3 was organized for control group.

Schools Variables. The schools were governmental, for both the two experimental and control groups, having similar educational, social, environmental conditions and homogeneous learning background to the participants, where children of economically similar background parents were enrolled. The schools selected for this study were from the same area.

Students Variables. The sample children in the experimental and control group were from the same grade and the similar age level, which is 7 – 12 years old.

To summarize, by designing robust controls, the internal validity of a study can be strengthened. External validity refers to the generalizability of the treatment outcomes to new participants, settings, and outcome measures (Kratochwill, 2010). On such threat to validity,: the participants selected for the study may not have accurately represented the population of interest. Sampling from a larger pool of schools and participants would have limited the extent of this threat by representing a wider variety of students (Pallant, 2011). The External validity of this study is established by carrying out experiments within the students' classrooms (real world settings) and with their regular classroom teachers. This study was conducted in real first-grade classrooms with everyday routines and with regular classroom teachers delivering instruction as like regular lesson time.

3.4. Participants and sampling

The study was conducted at three governmental primary schools in Addis Ababa, Ethiopia. The schools were close each other and had similar environmental, social, economical aspects as the pilot school. To select the sample schools, a non-probability judgmental sampling design technique was utilized, since it was pretty difficult for data collectors to glean truly random samples because of the diminished population size of students with MD from which to elicit participation**.** So, the schools were selected based on the following criteria, such as the accommodation of large students' population, delivering support to students with learning disabilities, and using MLC program**.**

Moreover, participants were chosen purposively with criteria in juncture of identification and group intervention. In the identification stage, all first grade class students were taken purposefully from the sample schools with a predetermined number 654. So as to get enough sample size, large predetermined number size of students is useful before data collection, since the prevalence rate of students with MD and its co-morbidity with reading difficulties is between 5% to 40 %. So, the sample size is expected between 32 to 262 students with MD and MDRD. The first grade level is opted since research confirm that the poor performance of students on simple mathematics problems at the time of completion of the kindergarten (KG) are more likely to show up poor performance in later grades in mathematics (Jordan & Levice., 2009; Morgan et al., 2009). Secondly, early grade one and two, children who are typically developing started solving straightforward problems using procedural methods such as counting (Mazzocco et al., 2008). Thirdly, it is possible to get rich information about the children's mathematics problems in the former grades, namely KG.

Screening occurred in stepwise fashion. First step, it was begun from the school screening experience document, as it was mentioned formerly, MLC program. From this program, the schools identified 78 students having problem with mathematics and reading. As a second step, assessment and support for students with SNEds in primary Schools (ASSPS) was screening tool, which is taken from MoE of Ethiopia. It was applied to discern students having mathematics and language problems by excluding co-morbidities except reading difficulties. Reading difficulties were made to be the part for the study as co-morbidities, namely MDRD, since MD is highly linked with reading difficulties and also to make the sample plausible enough. In the third stage, the identified students were further screened on a version of BANUCA (Räsänen & Natayi, 2011), see in the Measures Section. After passing these screening steps, and the following inclusion criteria are enormously important that each participant must meet to be eligible for study participation. The participants had:

- MD (score 30th percentiles and below in BANUCA).
- been enrolled in the first grade, and
- to provide informed consent for parents.
- no co-morbidities with other difficulties except reading.
- to speak Amharic.

Based on group intervention stage, the opted students from the inclusion criteria out of 78 students, 72 students were found as students with MD and MDRD. Two students were excluded because they could not speak Amharic and one had co-morbidities with intellectual disabilities and three of them scored above 30th percentile rank. To check the appropriateness of the sample size for this study, different existing related research studies give variant figures. Smaller samples are needed in experimental settings, presumably because sufficient control of extraneous variation is in place, and standard errors tend to be smaller (Marszalek, 2011). Specifically, Xin et al. (2017) indicated that through conducting a power analysis using an alpha level of .05 and an effect size of 1.25, a minimum of eight or nine participants in each group was sufficient to obtain a power of 0.87 to 0.91. To strength this, the present study's effect size and observed power was analyzed during the study of the effect of concrete fading instruction utilizing gabat'a in terms of condition, these were effect size of 46.3% and 12% improvement and observed power of 0.999 and 0.84 for CNC and arithmetic respectively (see Table 21 and Table 32) in the findings section. These showed that the sample size for the MANCOVA analysis was adequate (Green &Salkind, 2014). In addition, as stated in Mills and Gays (2019), a 2 by 2 experimental design with 20 participants per group (a relatively small number) requires at least 80 participants in total. Much has been written about the necessary sample size for factor analysis and correlation. Mills and Gay (2019) stated that the sample for a correlational study is selected by using an acceptable sampling method, and a minimally acceptable sample size is generally 30 participants. If validity and reliability are low, a larger sample is needed because errors of measurement may mask a true relation. The higher the validity and reliability of the variables to be correlated, the smaller the sample can be, but not fewer than 30. Field (2013) mentioned that correlation coefficients fluctuate from sample to sample, much more so in small samples than in large and the reliability of factor analysis is also dependent on sample size. In 'rules of thumb', Kass and Tinsley (1979) recommended having between 5 and 10 participants per variable up to a total of 300, beyond this number heedless of the participant to variable ratio, test parameters tend to be stable. In support, Tabachnick and Fidell (2012) agree that for factor analysis having at least 300 cases is comfortable and Comrey and Lee (1992) classified 1000 as excellent, 300 as a good sample size, 100 as poor. From the present dissertation, it was found that the results of a MANCOVA analysis indicate that there is a significant difference ($p<0.000$) between three groups in the post-test of addition (dot and symbolic) and subtraction (dot and symbolic) achievement Plausibly for this study, all the students ($n = 72$) who meet the selection criterion were the participants of the study. They were taken in experiment 1 and experiment 2.

In experiment 1, as to Xin et al. (2017), after the students with MD achieved the selection criteria, randomization was carried out to assign students into one of the two comparison groups. Similarly, random assignment of these 72 students into two study conditions (CIGO and control group) for the present study was occurred by stratifying into gender strata (male (M) and female (F)), then each stratum was further grouped into PMK (Y) and no PMK (N) and again stratified in their difficulty types (MD vs MDRD). So, the total strata were 2 x 2 x 2 equals eight. These were *MNMDRD (n=07), FYMDRD (n=12), FYMD (n=07), FN MDRD (n=10), FNMD (n=10), MYMDRD (n=10), MYMD (n=13), and MNMD (n=03).* Each participant in the stratum was randomly assigned in each two conditions utilizing simple lottery method. Ultimately, students were grouped into 36 and 36 participants in experimental group and control group, respectively. So, the number of students who were participated for post-testing in each condition was *CIGO (n =35) and* control group *(n = 36).*

In experiment 2, the random assignment of these 72 students to the three study conditions such as, AIGG, AIGO, and control group, were occurred by stratifying into gender strata (male (M) and female (F)), then each stratum were further grouped into PMK (Y) and no PMK (N) and again stratified in their difficulty types (MD vs MDRD). So, the total strata were 2x2x2 equals 8. These were *FYMDRD (n=12), FYMD (n=07), FN MDRD (n=10), FNMD (n=10), MYMDRD (n=10), MYMD (n=13), MNMDRD (n=07), and MNMD (n=03).* Each participant in the stratum was randomly assigned in each three conditions utilizing simple lottery method. Ultimately, students were grouped into 24, 24, and 24 experimental group one, experimental group two, and control group, respectively. So, the number of students who were participated for post-testing in each condition was *AIGG (n=24), AIGO (n=23), and* control group *(n=24).*

3.5.Measures

According to Mills and Gay (2019), delivering details of measures are important, including instrument's purpose, response format, and scoring. If the measures are adapted or adopted giving the name and associated acronym of instruments and providing the authors' names and the key reference source for the measure is necessary. The validity and reliability of each measure utilized is needed to be described with some details. The primary task of measures was to discern first grade students having learning disabilities in mathematics. Detail assessment of considering other aspects are also deemed necessary to be addressed. To measure the independent variable with respect to the dependent variable, there were multiform instrument were directed. The major tools were screening measure and dependent measures. The details are exploded as follows

3.5.1. Screening measure

Based on literature review, to screen out participants, in the case of students with MD, as explicated by Xin et al. (2017), it could be done through

(a) school identification of students experiencing substantial problems in mathematics, by looking into their mathematics recording

(b) scores below the 35th percentile on the Mathematics Problem Solving subtest of the standardized Achievement Test

In similar ways, in this section, three screening measures were enacted, including school academic recording, Assessment and Support for Students with SNEds in Primary Schools scale (ASSPS)**,** and Basic Numerical and Calculation Abilities (**BANUCA**) test battery.

School academic recording: Mathematics Learning Competencies (MLC). Student's former mathematics and other academic subject results recording were assessed, as a starting point. From the school student's recording documentation, below average math scorers and Mathematics Learning Competencies MLC assessment documents were the core focus. Proceeding from this, the first screening was done, gleaning students who scored lower in mathematics only and lower in both mathematics and reading from the school's academic and MLC recordings. For this purpose, student's scoring records was prepared. This recording was entirely academicals and then further additional comprehensive assessment was done by ASSPS.

Assessment and support for students with SNEds in primary Schools (ASSPS*).* Once, the school academic and MLC recording documents were assessed, besides ASSPS was applied. MD, reading difficulties, behavioral challenges, intellectual disabilities and writing difficulties were assessed by utilizing this tool, see Appendix A. The scale has description of each item. This scale was filled by the home room and subject teachers who know the student very well Translating the scale into Amharic is not needed, since the scale was filled by the homeroom and subject teachers who knew the students very well and who had followed high school till university level where the medium of instruction was English. They were asked to rate each item according to the following 2-point scale: (0) 'not observed', and (1) 'yes observed'. To screen out students, 14, 15, 20, 22 and 16 items were used for assessing reading difficulties, MD, writing difficulties, intellectual disabilities, and behavioral challenges, respectively.

Scoring was done for each yardstick. The highest possible score to be made was 14, 15, 20, 22 and 16 points for assessing reading difficulties, MD, writing difficulties, intellectual disabilities and behavioral challenges, respectively, while the lowest possible score is zero (0).The mid-scale value is 0.5 on a 2-point scale. Therefore, the cut-off value for low and high score was (0.5 x 14) points i.e. 7 points for reading difficulties and the rest 7.5, 10, 11, 8 for MD, writing difficulties, intellectual disabilities, and behavioral challenges, respectively. Hence, any student scoring below the cut-off value for respective disabilities classified as low score or below average.

Reliability and validity of ASSPS. This screening tool was taken from MoE of Ethiopia from the document of student's assessment and support for students with SNEds in primary Schools (MoE, 2017). No reliability information was found. The instrument aided in the collection of learning disabilities measure data. The overall instrument presented a 0.89 Cronbach coefficient rating level. The instrument and reliability rating of each are depicted in Table 6. The Cronbach coefficient rating level for each area of ASSPS was examined.

Table 6
Reliability of ASSPS Scale

		Reliability (pilot test)
		Cronback's alpha (α)
Total scale		0.89
Sub-scale	Reading Difficulties	0.78
	Writing difficulties	0.95
	Mathematics difficulties	0.84
	Intellectual challenges	0.96
	Behavioral challenges	0.82

Note: $\alpha \geq 0.7$ is reliable as suggested by DeVellis (2012)

BANUCA test battery. Basic **Nu**merical and **C**alculation **A**bilities (**BANUCA**)-Ethiopia is orchestrated as a test battery (Räsänen & Natayi, 2011). BANUCA is also an internationally recognized test battery (Räsänen & Chilala, 2003; Räsänen,, 2005) and has been applied different countries. The test is developed for the sake of group assignment and screening difficulties in basic numeracy for children at grades 1 to 4. Amharic and English version of BANUCA were put in use for this dissertation purposes. The test battery is organized the tasks to render an estimate of the person's skills in number related abilities, which in turn a spring board for the child's learning mathematics at school as well as utilizing mathematical skills needed in daily living. There are nine tasks exist in BANUCA, see Appendix B. The tasks are comparison (dots), correspondence, single-digit addition, single-digit subtraction, writing numbers (number line), comparison (numbers), matching spoken and written numbers, calculation multi-digit numbers, & arithmetic reasoning. The BANUCA's nine tasks has been partitioned into two short forms for children at different grade levels. An individual needs a more detail assessments, when an examinee's performance in the BANUCA test is poor. As it is stressed, the BANUCA alone is not enough for a reliable diagnosis, requiring other more measures.

Three different batteries are entailed in BANUCA to suit children at different ages and for children at different intellectual levels. The full battery has all nine tasks and then there are two short-forms. These short-forms are used for assessing basic number skills and arithmetic skills. In the test battery, there is no tasks, which requires verbal response.

With reference to the scoring, the level of performance has three levels scale. Levels are expressed in terms of percentile, average or above average performance (40 and above percentile rank), low performance (between 10 to 30 percentile) and finally extremely low performance with further analysis recommended (below 10 percentile).

The reliabilities and validities of BANUCA. The BANUCA screening measure was taken from MoE of Ethiopia document to use it as a test battery for assessing basic numerical and calculation abilities (Räsänen & Natayi, 2011). As shown in Table 7, the reliability of the BANUCA screening measure has been estimated based on test-retest reliability coefficient for the total scale and subscale with 79 items. The scores from each sub-scale were correlated and the coefficient of stability was calculated to be 0.92. The pilot study results indicated the instrument was reliable. The total scales and all the subscales have met the requirement of higher than 0.7 cut-off point suggested by DeVellis (2012).

Table 7
The Reliability of the BANUCA Measure with 79 Items

		Reliability (pilot test)
		Test retest reliability
Total scale	BANUCA	0.91
Sub-scale	Comparison: dots,	0.90
	Correspondence,	0.94
	Single-digit: addition,	0.87
	Single-digit: subtraction,	0.88
	Writing numbers: number line	0.94
	Comparison: numbers,	0.95
	Matching spoken and written numbers	0.89
	Calculation: multi-digit numbers	0.94
	Arithmetic reasoning	0.80

Note: $\alpha \geq 0.7$ is reliable as suggested by DeVellis (2012)

3.5.2. Dependent measures

Early Numeral Achievement Test. This instrument was used to measure mathematics achievement of students with MD, focusing on CNC and arithmetic. The Early Grade Mathematics Assessment (EGMA) instrument of Reubens (2009), BANUCA screening tool (Räsänen & Natayi, 2011), and *The Dyscalculia Assessment* (Emerson & Babtie, 2014) are standardized in terms of procedural and instructional requirements. Nevertheless, the contents of the assessment were organized based on the local context or local curriculum. Though all items were framed based on the operational curriculum content, the skills and concepts included in the assessment instrument were selected on the basis of what children should know and be able to do to develop proficiency in mathematics, and not on the principle of curriculum content coverage. So, this measure was organized pivoted on the specified sub-constructs and grade 1 mathematics textbooks.

Anchored in this, the test was made up of two parts: Part one, student background questionnaire; this is aimed at collecting some information about proxy factors of students' with MD**.** Students' age, gender, schools, language, PMK, and difficulty type are the part of the questionnaire. Part two has two sections, CNC, and arithmetic operation, respectively.

I) Counting and number concept (CNC): it includes procedural counting, conceptual counting, and number concept. The actual questions are provided in Appendix C.

1) Counting

Counting is the most basic skill required to build number sense. For counting, two ways of measurement were enacted, procedural and conceptual counting.

a) ***Procedural Counting***

As learned from the literature, the foundational skills under this category are oral counting, and missing numbers.

- ***Oral Counting (OC)*****:** This task focused on the counting skill and not on the concept or principle of counting. It was used to assess the students' ability of producing numbers in one-minute time to limit the counting fluency (as measured by accuracy and speed) of each child. Counting usually begins with number 1 and ends between 30 and 40. This is sufficient for this task and students are required to continue counting as fast as possible till the end of the one minute (60 seconds). The scoring, therefore, is based on the counting of the correct oral responses out of the total counted in 60 seconds or less depending on the timing when the child starts counting wrongly. A child is allowed to continue counting until the end of the one minute provided he or she is counting correctly. The maximum number counted correctly marks the child's fluency or competency of oral counting within one minute. Counting down was also measured and it requires children to count down from 10, and then from 20, as quickly but as accurately as possible.
- ***Missing Number (MN)*****:** This task focused on two elements: (1) order of numbers, and (2) identifying the number symbol missed in the list. The scoring depended on the identification of right and wrong answers, without time factor, to allow each child deals with all the items in the question paper.

b) *Conceptual Counting*

It encompasses three key principles of counting skills.

- ***One-To-One Correspondence (OTOC)*:** This is also counting and timed to 60 seconds or one minute. It differs from oral counting in that counting is done using objects (dots in this case) and not oral counting. It was limited to 30, arranged in six columns and 5 rows. In this sub-test too, a child was allowed to continue counting until the 30 objects and/or the 60 seconds were finished provided that the child did not make any mistake in the process of counting. Though the last number counted correct within the time marks the fluency of the child, competencies of children who finished counting correctly before the one minute time was over.
- **Cardinality (C):** This task tries to assess students' counting skill to understand the number of objects in a set. The child should count the number of objects in a set and tell how many objects are in the set. It is not timed for the students to deal with different questions. There are three possibilities here:
    a. a child counts correctly and provides the correct number of objects in the set,
    b. a child counts correctly but could not tell the number of objects, and
    c. a child may not finish counting objects correctly.

Scoring depends on the number of right and wrong responses out of the total tried.

- **Stable Order (SO) :** (disruption of the counting order), the numbers till 20 are randomized in left column and the child is asked to order the numbers in the right column. A child's correct answer was scored when they ordered the number correctly from the total.

2) Number Concept (NC)

Number recognition and quantity discrimination are also the other focus for trying to relate number symbols (numerals) with counting concepts and measuring the ability of children to compare magnitude either using counting objects or numbers, respectively.

a) Number Identification (NI). This tries to relate number symbols (numerals) with counting concepts. The numbers were randomly selected (from grade 1 mathematics textbook) and placed in a grid. The child was, therefore, to name numbers listed in the given sequence. The numbers (all 1 through 30) were randomly arranged in a 5x6 number table and copied to the student stimuli for congruence purposes. This is a timed test to check students' fluency to name numbers within 60 seconds. A child should stop iff he or she misses all the numbers in the first row or if the time is finished. The scoring depends on the number of correct responses from the total attempted in the given one minute time.

b) ***Quantity Discrimination (QD)*** refers to measuring the ability of children to compare magnitude either using counting objects or numbers. However, quantity discrimination using object groups is similar to the oral counting skill. Thus, quantity discrimination using numbers was the preference in this study. Note that this was not a timed test; it simply focused on judging their understanding of magnitude from the responses of each child. Scoring was based on number of correct answers out of attempted.

The reliability and validity of CNC achievement measure. The CNC achievement test was organized with cooperation of first grade mathematics elementary teachers as previously mentioned. This test includes oral counting, missing number, cardinality, one to one correspondence, stable order, number identification, and quantity discrimination. The content validity was evaluated by three PhD students, two from mathematics and one from measurement and evaluation. The reliability of test through test–retest is shown in Table 8.

Table 8

The Reliability of the CNC Achievement Measure with 30 Items

		Reliability (pilot test)
		Test retest reliability(α)
Total test		0.92
Sub-test items	Oral Counting	0.87
	Missing number	0.95
	Cardinality	0.89
	One to one Correspondence	0.98
	Stable order	0.94
	Number Identification	0.85
	Quantity discrimination	0.88

Note: $\alpha \geq 0.7$ is reliable as suggested by DeVellis (2012)

II) Arithmetic operation. The detail information related to the actual questions are provided in Appendix D. Arithmetic (addition and subtraction by dot and symbol) were the main part. It was not timed and scoring was about the count of right responses out of the total items.

Symbolic Addition, this system allowed students to use anything for counting while dealing with the addition activities. It was not timed and scoring was about the count of right responses out of the total items attempted. There were 15 items with a heading of summing up numbers by counting and fill in the correct answers in the spaces provided, then adding two single digit numbers, not exceeding 20; adding 3 single digit numbers, not exceeding 20; adding 2 digit numbers to 1 digit number without carrying over, up to 30; and adding 2 digit number to 2 digit number without carrying over, up to 30 were the main part of the test items.

Dot Addition, it is almost similar with symbolic addition, the only difference from the symbolic addition in that the students are allowed to add dots rather than numbers. There were 15 items with a heading of summing up objects by counting and fill in the correct answers in the spaces provided then adding single, double digits within 30 without carrying over were the titles of the items.

Symbolic Subtraction, similar to addition, there were 15 items related to subtracting numbers and filling in the correct answers in the space provided, then subtracting two single digit numbers, not exceeding 20; subtraction on three single digit numbers, not exceeding 20, subtracting two digit numbers to one digit number without carrying over, up to 30; and subtracting two digit number to another two digit number without carrying over, up to 30 were the parts of the items. Point to focus, during the subtracting of three single digits, to avoid the result of negative numbers, subtrahend should be less than minuend.

Dot Subtraction, similar to dot addition, there were 15 items related to subtracting objects by counting and filling in the correct answers in the space provided, then adding single, double digits within 30 without carrying over were the titles of the items.

The Reliabilities and Validities of Arithmetic Achievement Measure. Reliability analysis was conducted to confirm the internal consistency of the items in the given arithmetic achievement test. The test was set in cooperation with first grade mathematics teachers. This test includes addition and subtraction (dot and symbolic).Validity of the test was checked by two PhD students in the field of mathematics education, and measurement and evaluation experts. These experts confirmed the adequacy of the content validity, wording, and response format. But, formerly, the entire items were symbolic, dot addition and dot substaction items were added by considering mental gabat’a . The test- retest reliability was used to calculate the reliability of the test and was found 0.98. The details are depicted in Table 9.

Table 9
The Reliability of the Arithmetic Achievement Measure

		Reliability (pilot test)
		Test- retest coefficient
Total scale	Arithmetic achievement	0.98
Sub-test	DA	0.98
	SA	0.99
	DS	0.97
	SS	0.96

Note: α > 0.7 is reliable as suggested by DeVellis (2012); DA=dot addition; SA=symbolic addition; DS=dot subtraction; and SS=symbolic subtraction.

Early Mathematics Motivational Scale (EMMS). The EMMS was prepared to gauge the effect of concrete fading intervention on motivation for students with MD.This scale was drawn and categorized based on a self-determination continuum (Guay et al., 2010) and the subscale primary school mathematics motivation scale of Ersoy and Oksuz (2015). The scale of Ersoy and Oksuz (2015) has an overall internal consistency coefficient of 0.94. It measures the motivation along three major attributes of intrinsic motivation (IM), identified regulation (IR), and controlled regulation (CR). Children were asked to indicate the extent to which each item applied to them, with respect to the following scale ***(0) 'no', (1) 'sometimes' and (2) 'always'***. Forward translation was made. The initial translation from the English language to the Amharic target language was made by two independent Amharic language translators. More information related to actual questions of the scale are provided in Appendix E. So, the highest possible score to be made was 22, 20, 18 points for assessing IM, IR and CR, respectively, and 60 points in total, while the lowest possible score for each case is zero (0).

The Reliabilities and Validities of EMMS. Before, the mathematics motivation scale was applied, it was formed, adapted, and validated content wise by experts in the field that considers Ethiopian culture and custom and then reliability test was also performed. The scale was adapted specifically for first grade students with cooperation of mathematics elementary teachers and the school psychologists. The content validity and wording of the 33 items were reviewed by two independent experts, viz., experts of one doctoral student from psychology and one mathematics teacher, who had not initially participated in adapting of the items. These experts confirmed the adequacy of the content validity, wording, and response format. However, three items were discarded **viz.,** *I can build up a connection between mathematical topics and topics in other subjects, when I get stuck in a topic in mathematics I* *investigate that topic from different resources, and I can build up a connection between my current learning and previous learning in mathematics were discarded*. This is, because, it was considered difficult for them to understand.

Moreover, item analysis was also performed to assess the performance of individual test items on the assumption that the overall quality of a test derives from the quality of its items. As a result of separate exploratory factor analyses (EFAs) of EMMS items using principal component axis with Oblimin rotation were performed for each sample to identify the measures. Firstly, the results of the Kaiser- Meyer-Olkin ,KMO (= 0.74) and Bartlet ($p <$ 0.000) test analysis showed that factor analysis was doable. EFA with Oblimin rotation showed that all of items were loaded over |.40|, depending of the number and the type of factors. Among them, 27 items were loaded in only one factor and three items (items 1, 2 and 3) were loaded for the other factor (see Table 10). As presented in the Table 10, the sum of the scale factors' eigen values was 15.03, the total percentage of variance explained was 50.2, and the factor loads of the items varied between |0.40| and |0.84|.

Table 10
Exploratory Factor Analysis Results of EMMS

Item Number	Factor Loading	Item Number	Factor Loading	Factor Loading
IM10	0.843	IM4	0.635	
IM12	0.831	IM5	0.604	
IM13	0.808	IM15	0.600	
IM7	0.804	IM14	0.600	
IM19	0.793	IM9	0.577	
IM8	0.785	IM26	0.543	
IM18	0.759	IM30	0.635	
IM20	0.728	IM23	0.604	
IM25	0.718	IM24	0.590	
IM11	0.686	IM28	0.487	.
IM27	0.684	IM29	-0.401	
IM22	0.677	IM1		.528
IM17	0.671	IM2		.466
IM6	0.659	IM3		.630
IM21	0.647	Eigen value	12.06	2.97
IM16	0.645	% of variance	40.21	9.99

Ultimately, the overall internal reliability of the EMMS scale was 0.90. Cronbach's alpha for each subscale were presented in Table 11. The results indicate that the EMMS has very highly acceptable levels of content validity and also provided evidence that the EMMS has acceptable levels of internal consistency.

Table 11
The Reliability of the EMM Scale with 30 Items

		Reliability (pilot test)
		Cronback's alpha(α)
Total scale	" EMMS"= Early Mathematics motivational scale	0.90
Sub-scale	"IM"= Intrinsic motivation;	0.88
	"IR"= Identified regulation;	0.92
	"CR"= Controlled regulation.	0.91

Note: $\alpha \geq 0.7$ is reliable as suggested by DeVellis (2012)

3.5.3. Measures of Fidelity of Implementation

This scale was prepared for the purposes of measuring the quality of the implementation of the intervention. It is a two point scale, using yes (1) / no (0) response rating scale (see Appendix F). The highest possible score to be made was 12, while the lowest possible score was zero (0). The checklist was adapted from Mellard (2010), but no information about the reliability of the instrument. It was organized initially in cooperation with the school pedagogy expert. Eventually, fidelity of implementation of the intervention checklist was validated by two PhD students from curriculum and instruction, and measurement and evaluation. The reliability of fidelity of implementation as an instrument has been estimated based on Cronbach's alpha of the total scale was 0.90 and subscale with 20 items was shown in the Table 12.

Secondly, fidelity of implementation was gauged by primary school math teachers. They carried out observation on treatment sessions for each tutor for 3 sessions for 4 weeks intervention to assess the fidelity of implementation of specific performance indicators. The reliability of the fidelity of implementation, the inter-rater reliability was calculated using cronback's alpha having a value of 0.91 (see Table 12).

Table 12
The Reliability of the Fidelity of Implementation

		Instructional intervention	Instrument
		Inter-rater reliability (pilot test)	Internal consistency (pilot test)
		Cronback's alpha(α)	Cronback's alpha(α)
Total scale	Fidelity of implementation	0.91	0.90
Sub-scale ‘	Entailed adherence	0.90	0.92
	Exposure	0.93	0.89
	Quality of delivery of lessons	0.86	0.87
	Program specification	0.88	0.91
	Student's responsiveness	0.94	0.91
	Reinforcement techniques	0.87	0.88

Note: $\alpha \geq 0.7$ is reliable as suggested by DeVellis (2012)

3.6. Materials and Equipments

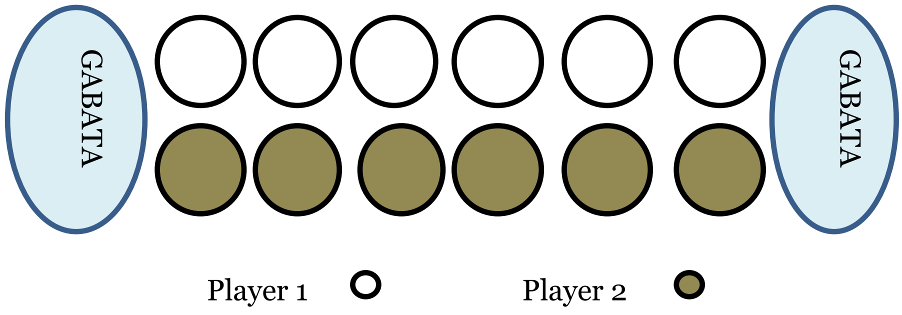
The mathematics intervention instruction materials was developed after reviewing the grade one mathematics curriculum, discussion with grade one mathematics teachers, and their yearly plan for teaching mathematics in the selected classes. All the elements of CNC and arithmetic targeted in intervention sessions were the same as those targeted in the control classes, teachers' daily lesson plans with the respective notes were crosschecked against each day's intervention plan and weekly briefings with the mathematics teachers were held to ensure no deviations were made between the plans. Weekly assignment and exercise were also prepared. In each intervention instruction sessions, there was the activity sheets based on the associated daily lesson objectives of the lesson. These activity sheets were in turn used to create a bigger picture of the performance of the students then after weekly assessment and the posttest was prepared to assess the effect of the treatment.

The gabat'a board, as an instructional aid and games**,** has 60 cm in a row by 24.80 cm in column for game purposes. lt includes six holes in a row and two holes in column and a total of 12 holes, each having 6 cm diameter. They have 10 spaces of identical size of 2 cm between them along a row and 5 identical spaces of 8 cm along a column and two stores with 8 cm by 4 cm by diameter (see Figure 7). Whereas for the purposes of instructional aids, the *gabat'a* had not so much differences in the size of the holes but the gabat'a was divided into two equal parts having 3 holes in a row, 2 holes in a column, and one store hole.

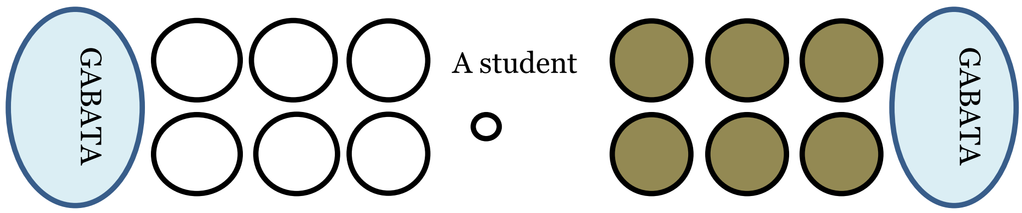
Figure 7

The Gabat'a Structure and Size for Game and Instructional Purpose

a) Game purpose



b) Instructional purpose

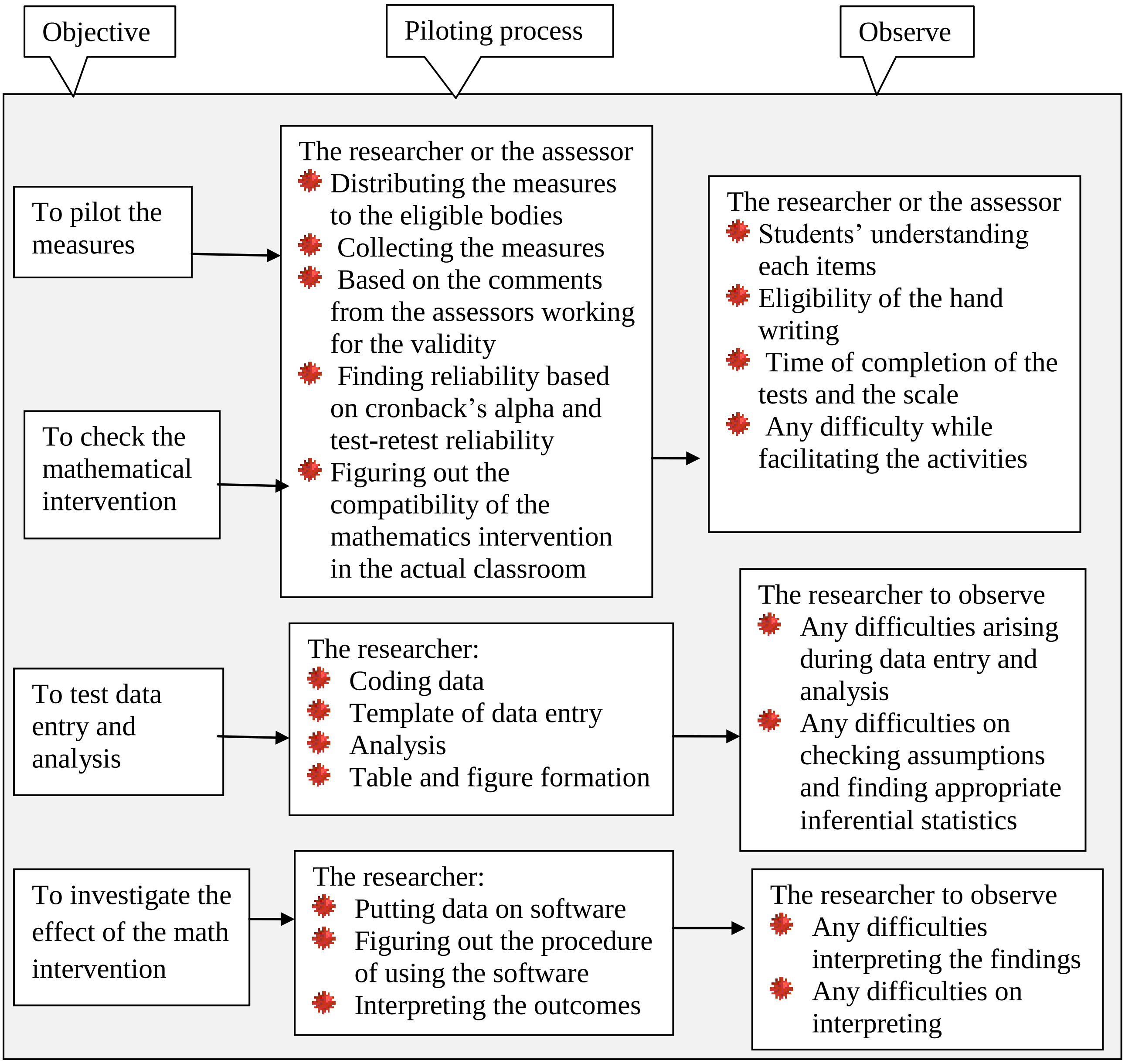


3.7. The Pilot Study

This study was carried out for six weeks having two basic intentions, for pilot testing the measures and mini pilot study. The flow chart of the pilot study was depicted in Figure 8. The pilot study was conducted at one governmental primary school. After following all the screening steps as aforementioned in the main study, only 29 grade one students were identified. The opted students from the inclusion criteria out of 29 students, 23 students were found as students with MD and MDRD. On account of the small sample size, only two groups were taken, that is, 11 and 12 for AIGG and control group, respectively. The experiments were carried out for a month, due to time constraint, only certain contents were covered, only entailing arithmetic for two groups. Besides, co-rrelational analysis was made as well.

Figure 8

Flow Chart of the Pilot Study



During the pilot test, tests and scales were checked their reliability and validity. Using cronback's alpha , test-retest stability, and inter rater reliability (see Tables in each measure section), reliability was figured out. To do on their validity, copies of the instruments, as aforementioned were given to experts in the fields of mathematics, curriculum and instruction, and educational measurement and evaluation for validation. These experts were requested to vet items of the measures in terms of appropriations, clarity of words and relevance to the study objectives. Accordingly, some unclear items were modified to minimize item ambiguity and repetitive items were also rejected. Thus, item improvement on measures was made based on three types of inputs:

(a) the report of the assessors on the clarity of an item during testing,
(b) the analysis of the match of responses of the respondents to each item, and
(c) the analysis of the relevance of variables included in the measure formats to the study objectives and analytical setting.

After the reliability and the validity of the measuring instrument were achieved, the experimental pilot study was carried out so as to assess the effect arithmetic instruction using gabat’a on student’s with MD CNC and arithmetic achievement, and early mathematics motivation. Later, the sample participants and the school were not taken as the part of the main study.

The major findings of the mini pilot study give main emphasis on the selected variables from the main study. Only some parts of experimental and correlational design were added for analysis and interpretation. Thus, the major findings showed that concrete fading arithmetic intervention using gabat’a has a significant effect on arithmetic achievement and early mathematics motivation. In terms of gender, the result showed a non-significant difference between them. With respect to correlational results, within the addition and subtraction constructs, the correlation was highest, the same was true for cross correlation. In addition, the multiple regression findings indicated that addition had a unique significant contribution for subtraction than counting.

In conclusion, for this pilot study, the results indicated that all the tests and scales were reliable and valid instruments in measuring early numerical achievement and early mathematics motivation. The tests and scales are a promising measure with good items homogeneity, internal consistency and a meaningful pattern of validity. The study came out with significant results as the correlation coefficient was found to be significantly high witnessing the high reliability and validity of the test. Because of getting sufficient number of students, 30 items EMMS passed through exploratory factor analysis (EFA) with Oblimin rotation showed that all of items were loaded over |.40| depending of the number and the type of factors. All items of the instrument (EMMS) are valid and highly reliable. In addition, testing the effectiveness of the concrete fading arithmetic intervention; it was found that the arithmetic intervention using gabat'a has a significant effect on arithmetic achievement and early mathematics motivation. In terms of gender, the result showed a non-significant difference between them.

3.8. The Experimental Intervention and Data Collection Procedures

The procedure of this study carried out in three phases. It began from delivering of formal letter to the experimental sites in order to get consent from the schools authorities, to the elaboration of the key intervention strategies and protocol, and finally to the administration of data gathering through the pretests and posttests of three groups.

Phase I: Data collection, screening, assessment, and testing Procedures, in this phase, official letters that clarify the purpose of the study were handed over to the primary school authorities and teachers in order to get their consent for conducting the study. The mathematics teachers who were delivering lessons for primary grade level, special needs experts, school director, and vice director were identified and introduced the objectives of the study as a whole and the instruments in particular.

In the procedure, first, the screening and identification of students at risk of MD were done, employing MLC recording and ASSPS scale as the initial screening measure. A scale of the ASSPS characteristics was provided to them to identify students having mathematics problems among the other co-morbidities. After MLC recording and ASSPS results, further assessment was conducted to identify students having mathematical problem using BANUCA. BANUCA was distributed to all students who were identified as having mathematics problems from the previously mentioned tools. Finally, these students were considered as students having MD. Secondly, informed consent was made with parents (see Appendix G). They were informed of the method of instruction that was used in the treatment group of participating classrooms, but were blind to their student's placement in a treatment or control classroom. Participating students were not informed by the researcher nor by their teachers regarding the method of instruction used in their classrooms. Thirdly, pretesting was set for two purposes to measure CNC and arithmetic achievement and early mathematics motivation. The tests were distributed to all two groups and three groups, and it was carried out for an hour to take early CNC and arithmetic measures, respectively. The early mathematics motivation pretest, the students filled EMMS. The data collectors made sure that the students add all necessary data, including demographic information. Eventually, all groups of students with MD received the posttest measure, the same way as pretest.

Phase II: The intervention phase, there is a need for a suitable intervention to address early MD. It can be drawn from local teacher's guide and researches on the nature of MD to inform the organization of appropriate interventions. Two main tasks were accomplished,

i. Interventionists', assessors' and students' with MD training

The training was conducted for math interventionists, data collectors, and students with MD for four days. Three trainees and one trainer were recruited; three of them were math teachers as interventionists and one as a trainer of gabat'a game. The criteria of recruitment are good experience of handing and teaching students having learning difficulties in mathematics, and tolerance and persistence in helping these students. At the beginning, training for the interventionists and its time-line consisted of

a. an explanation of the program by the researcher (brief for 10 min).
b. a description of the lessons by the researcher (see appendix H, 2 hours for interventionists).
c. an explanation of procedures for early CNC, and arithmetic CRA with explicit, systematic instruction using gabat'a with its game and without the game (4 hour).
d. an instructional strategy and materials (1 hour, for the contents see intervention protocol section).
e. an organization and guideline of gabat'a for teaching purposes and game (2 hours, for the contents, see intervention protocol section)

The training was conducted on the major areas on CNC and arithmetic achievement for the interventionists and it was based on how to teach students with MD by enacting CRA with explicit instruction through accompanying instructional materials and how to make them play gabat'a. The control classroom teacher did not receive specialized instructional training, but conducted the math lessons based on regular first-grade text over the intervention periods. Concerning the assessors, a training session on all measures was carried out. The researcher organized a day long training for the data collectors or assessors to familiarize them with the nature of the data, coding system and expected level of accuracy. The morning session was completely devoted to discussions on the nature of the data, objectives of the research, coding systems and practicing. The guided practice was made using the pilot data (already in SPSS format) to compare with and judge the accuracy levels of the data entry clerks. In the afternoon, the data entrants started independent activity under a close support and monitoring by the researcher. It was after such a process of training that the data entry was started under the supervision of the researcher.

In the other part, they were trained on using stop watches in the timed sub tests, adjusting the time to one minute for down count, switching on when the child starts responding, stopping the watch when appropriate, recording remaining seconds if any, etc. The stopwatch used was selected on the basis of easiness to use, eligibility of the readings, and its ability to produce sound when the set time is finished. Apart from the timed subtests (subtasks), the remaining parts focused on limiting the nature of student's responses (right or wrong) to the given items.

For participants with MD, the experimental group took two orientation sessions (40 minutes each), during which they got training on how to use gabat'a for instructional purposes and gabat'a game and practice by playing with it (one day).

ii. Instructional intervention protocol

This protocol is orchestrated for the dissertation purpose to carry out mathematical intervention for children with MD and it holds up to look into whether the intervention has effect on children's with MD early numeral achievement, and early mathematics motivation or not. The intervention, in this case, is both instruction and game. For children with MD, it is suggested in the aforementioned literature reviews that CRA with explicit instruction is a most appropriate ways of intervention. CRA with explicit instruction using gabat'a in tandem with its game and without game was the most helpful. The concrete fading and explicit nature of the instruction, the teacher/ interventionist introduces the topic of the daily lesson, explains how to solve the problem in question and gives an example of good solution, and strategy with gabat'a board aid. In the present study, one experimental group was opted from the three groups for arithmetic intervention or two groups for CNC intervention. In this group, a board game (gabat'a) was added as an instructional aids and game to play right after the instruction for AIGG. The other experimental group received remedial teaching by gabat'a as an instructional aid but no game play, AIGO or CIGO.

The lesson contents, the interventional instructional objectives, and the instructional time-line were arranged predominantly based of local context or local curriculum of grade one text book and teacher's guide to suit students with MD (for more details, see Appendix I). Besides, the EGMA instrument of Reubens (2009), BANUCA screening tool (Räsänen & Natayi, 2011), and *The Dyscalculia Assessment* (Emerson & Babtie, 2014) were referred as an additional guide for such arrangements. Intervention sessions were taken place over a maximum period of 18 weeks as of November, 2019 after students getting experience and adapting the classroom and school environment within a quarter term. They received intervention services on Monday, Wednesday, Friday, for an hour each day for AIGG experimental group, i.e. 45 min for the lesson and 15 min for the game. 45 min for experimental group receiving remedial teaching by gabat'a as an instructional aid only, and 45 min for control group were allocated. Sessions were scheduled after the end of class, completing two interventions and one control sessions and per day. Sessions were conducted at the school MLC center and/or other arranged classroom in the school. Only the recruited three math teachers as interventionists implemented the interventions.

General Objectives of the Intervention. The general objectives encompass a bit much area in terms of breadth and depth. These objectives are intended to make the child to acquire the basic math skills, viz., counting numbers more than 100, reading and writing numbers in hundreds, calculating numbers in tens, identifying place value, solving word problems, and formal written numeracy. Based on the children's present level of performance and the target needs of a children to be intervened is CNC, simple addition and subtraction. After this intervention is implemented within 18 weeks, students with MD and MDRD will be able to:

- Count numbers till 20 and more.
- Identify numbers till 20 and more
- Compare numbers till 20 and more
- Calculate numbers within 20 and more, addition and subtraction

. ***Intervention Strategies.*** It was organized using CRA frame-work, encompassing *physical gabat'a as a concrete (C), mental gabat'a as representational (R), and most efficient min counting strategy and verbal counting strategy as an abstract (A).*

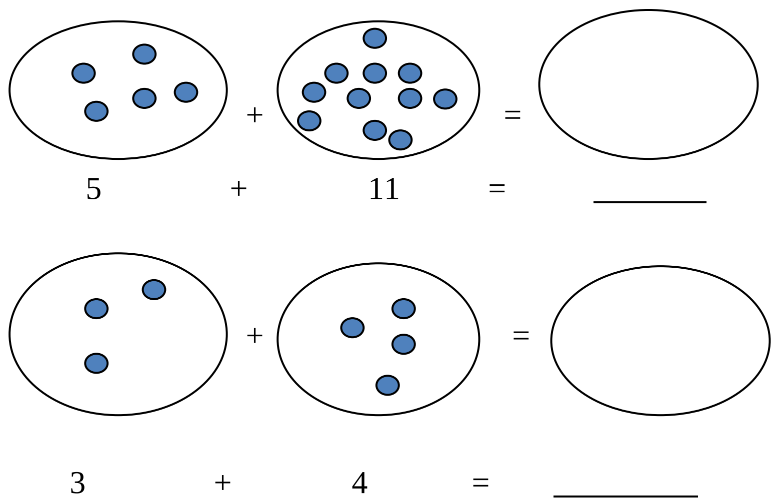
i. **Oral counting and number naming strategies** : this is only for the instruction of CNCs, the students learned counting one, two, three forwards and backwards in 1s, 2s, 5s and 10s by songs and hundred counting board etc. The students were also asked to read and write numbers from hundred boards. To discern numbers, a flash card number as well as a plastic number were used. For the purpose of comparing number, the interventionist puts a number of beads (objects) with different quantities in different holes inside *gabat'a* and made students to tell which hole contains the bigger number.

ii. **Physical *gabat'a* strategy**: this is a concrete stage. For conceptual counting, addition and subtraction, the child got practice by physical counting of the beads and put in the hole of gabat'a and associated the appropriate physical plastic numbers. The interventionist puts the number of beads (objects) in each hole and making the students to insert the plastic number for cardinality purposes. For the case of one to one correspondence, counting each bead and putting in the store of the gabat'a. After conceptual counting, the gabat'a plays a crucial role for addition and subtraction, for example putting the number of beads (four beads) in one hole and (two beads) in the other hole, taking both of the numbers from their holes and putting together to the other hole gives their sum by counting the beads, that is six beads. It is possible to do the horizontal and vertical addition and subtraction. Taking all the beads in one's and ten's holes into their corresponding holes, without carrying over.

iii. Mental gabat'a strategy (Dot counting). This strategy is related to representational stage. In this case, the child got practice with-out physical contact with beads and the holes but rather mentally counting the beads and putting the result in the hole and associated them with written numbers. The *gabat'a's* structure was drawn and the holes and the beads were drawn as circles and dots, respectively. The students count the dots tell or put their corresponding number magnitude in the circle and they count all the dots in circle and tell the sum (see Figure 9) and their difference too. Like the physical gabat'a, horizontal and vertical addition and subtraction were done by simple counting the dots in one's and ten's.

Figure 9

The mental gabat'a for addition



iv. Min counting strategy. The child practiced adding or subtracting number counting from the larger addend, regardless of whether the larger addend appears first or second. For example, adding 2+6= 8 (6,7, and 8). They can do verbally or counting dots from the larger addend.

v. Verbal counting strategy. In this strategy, the child only enacted verbal counting; he or she could use the min-counting strategy starting from larger addend.

Lesson Scheme. The lesson scheme for teaching CNC and arithmetic are organized in tables (see Appendix H). But, the lesson scheme of counting, adding and subtracting number using gabat'a to mental gabat'a (procedural counting wasn't applied) and mini and verbal counting strategy was applied for arithmetic only. The instruction module consists of two units: CNC (38 lessons), and arithmetic: Addition (10 lessons) and Subtraction (8 lessons).

Organization and Guidelines of Gabat'a for Teaching Purposes and Game. The gabat'a was organized for two purposes, instructional purpose, and cultural game.

(i) Gabat'a for instructional purpose

For this purpose, the gabat'a was arranged without losing its cultural value. It was cut into two half, having one store and six holes (see Figure 7). Each student uses one half part for conceptual counting, addition and subtraction. The following are the guideline how to instruct them.

- ✓ Tell the students about the instructional purposes of the gabat'a and let them also to identify the holes and the beads and their purposes too.
- ✓ Let them know the division of gabat'a into two for instructional purposes, they receive the half part of gabat'a.
- ✓ Count the number of beads in each hole and put the corresponding plastic number, this is for cardinality instruction.
- ✓ Ask the students to simply count the number of beads till 30 and put in the hole.
- ✓ Collect the number of beads in the first two holes and put them all on the third hole and count the sum, this for horizontal addition.
- ✓ Subtract from the first hole and put in the second hole vertically and count the first hole, which is the difference.
- ✓ Turn the half part of the gabat'a vertically and you have then two 3 holes, vertically.
- ✓ Then, for vertical addition purpose, collect the number of beads in the first two holes and put them on the third hole (that is the sum).

ii) Gabat'a as a board game

The two half gabat'a boards rejoined for the game purpose. Thus, it has 12 holes, 2 stores and they can play a game. The following is the guide how to play gabat'a.

a) Introduce gabat'a for two students and let others observe. By watching, the rules of playing, simply, can be learned. Modeling each step is the best way to teach gabata.

After the completion of this modeling, the teacher can guide the observing students to take turn to play too.

b) Ask students to write or orally describe their reactions to playing gabata. Specifically, direct them in their reactions towards mathematical investigations.

c) Rotate the pairing of players. Gabat'a is socially oriented and can be used to have children with learning disabilities and without learning disabilities work together in a non-threatening environment.

d) Monitor students as they play gabat'a to ensure they are playing properly and safely.

For control condition, during the intervention sessions, students in the control condition remain in their business as usual routines. Conspicuously, the major difference between the intervention and control groups was the approach of the instruction.

Phase III**: **Post-tests were administered right after the completion of the intervention. All measures were administered individually. The measure of CNC, addition and subtraction, early mathematics motivation were done at pretest, and immediate posttest.

In conclusion, this intervention protocol is enormously important to guild the intervention process for this dissertation purposes. It comprises three areas; CNC, addition, and subtraction with their respective methods, and materials. Enacting with the appropriate materials, interventionists on the time-line, it turns out to be effective. In between, daily, weekly, and monthly activities were used. On this purpose, instruments were prepared separately for pretesting and post-testing.

3.9. Data Analysis

3.9.1. Data Entry

All the important data were gleaned using different measures. The responses were categorized in terms of pertinent variables, viz., students' background information, pretest, and posttest of student's early numerical achievement, and motivation performances. Thus, data entry template created using the statistical software called Statistical Packages for Social Sciences Statistics (**SPSS**) **24.0** included four main categories of the data sheets.

a) Demographic information of the students with MD are sex, age, PMK, difficulty type, and first language status.

b) The key independent variables such as instructional approaches (instruction by gabat'a and gabat'a game, instruction only by gabat'a) and test time-line (pretest and posttest).

c) The dependent variables directly related to early numeral achievement (CNC and arithmetic) and early mathematics motivation of students with MD.

d) General coding variable values, coding variable names, etc.

The researcher created data template and coding system (in SPSS software) while the data collection was on process. After data collection and checking up for completeness and usability of the hard copies from each group was done.

3.9.2. Data Analysis Techniques

Through the application of SPSS software 24.0, the following procedures were used to analyze and identify major findings of the present study. The significant level for all tests were set at the $P < 0.05$ level.

I. Descriptive statistics such as; percentages, mean, standard deviation, skewness, kurtosis, normality test, and demographical data for CNC, arithmetic and early mathematics motivation were in use.

II. Using BANUCA test, students' scores were collected. Based on students' percentile ranks of 30^{th} and below were discerned and categorized as MD for first graders.

III. By enacting cronback's alpha, test-retest reliabilities, and inter-rater reliabilities, the reliabilities of different measures were assessed, such as reliabilities of BANUCA screening measure, ASSPS, CNC and arithmetic achievement measure, early mathematics motivation measure , and fidelity of implementation checklist.

IV. Preliminary analysis was carried out to check whether the pre-intervention group equivalency was achieved or not, subsequent to randomization. This was done based on the score of pretest in terms of three groups, gender, difficulty type as well as PMK of the students.

- A **chi-square test for independence** compares the observed frequencies or proportions of cases that occur in each of the categories. In this study, it was utilized to examine for the possible differences on the pretest group equivalency in terms of size across demographic subgroups such as, gender, difficulty type, PMK, and language status.
- **A set of independent MANOVA** was run to test the difference between the three groups' scores to show the two experimental groups and the control group scored similarly on the measures of CNC, arithmetic and/ or early mathematics motivation.

V. In this study, to test the first and second hypotheses about the effects of early numerical instruction using gabat'a on CNC and arithmetic achievement, and early mathematics motivation, MANCOVA is the appropriate analysis when the independent variables are categorical and the dependent variables are interval or ratio. It is a useful test to compare two or more groups when there are covariates and two or more dependent and independent variables. A covariate is an independent variable that is not controlled by researchers but affects dependent variables. Data were input into SPSS version 24.0 and statistical tests of MANCOVA were used to test the study hypotheses. That is, specifically, to test the first and second hypotheses about the effect CNC, or/ and arithmetic instruction using *gabat'a* on achievement, and early mathematics motivation. MANCOVA were used with the following variables**.** Dependent variables are early numerical achievement (CNC and arithmetic), and early mathematics motivation. The instructional approaches have two to three levels such as CIGO and control group for CNC instruction and AIGG, AIGO, control group for arithmetic instruction, difficulty type (MDRD, and MD), gender (male and female), and PMK (yes or no) were used as independent variables.

To test the overall effectiveness of the early numerical intervention, a mixed repeated MANCOVA was conducted in two approaches, separately for both CNC and arithmetic. First, 3x2 MANCOVA and 2x2 MANCOVA on the scores of arithmetic and CNC achievement was put in use through taking individual differences as covariates. It is repeated since the scores of same students with MD were taken at experimental pretest and immediate posttest. Both main effects and interaction effects were closely examined. If the interaction term is found to be significant like the main effect, pair-wise comparison analyses would be conducted to determine where the significant differences lie, the comparisons were done as part of MANCOVA output to compare the CNC and the arithmetic achievement between CIGO to control, and from AIGG to AIGO, AIGG to control and AIGO to control respectively. Moreover, a mixed (2 or 3) x2x2x2 MANCOVA was also employed to test the effect of individual differences on early numeral achievement and early mathematics motivation across conditions (CIGO and control group for CNC; and AIGG, AIGO and control group for arithmetic) and Time (pretest and posttest), putting in to consideration age, language status as covariates. In detail, it was taken CNC and arithmetic achievement, early mathematics motivation as dependent variables, whereas groups, gender, time, difficulty type, PMK, as independent variables.

Before conducting the MANCOVA, the basic assumptions needed were checked (see the result section). The statistical assumptions that were initially applied to the dependent variables were the multivariate assumptions of MANCOVA. The multivariate assumptions of MANCOVA are similar to the univariate assumptions of ANCOVA. They are;

1) independence of observations of the dependent variable,
2) normal distribution of the dependent variables and
3) equal variances and covariance among treatment groups of the dependent variable (Hair et al., 2014).
4) In addition to satisfying the statistical assumptions, the dependent variable data must also be analyzed to determine the existence of extreme observations (outliers) which may distort the analysis (Hair et al., 2014).
5) linearity between sets of independent and dependent variables
6) missing of data

These assumptions might be violated or not, different testing procedure is utilized. The **first** assumption tested is the independence of observations of the dependent variable. Independence of observations is achieved through a between-subjects design to test differences with respect to experimental groups, gender, difficulty type and PMK; and random assignment of participants to each of the treatment groups by applying stratified randomized design. In addition, each participant worked individually and performed the experimental task at one time. As a result, each of the observations is independent of all other observations for the dependent variables.

The **second** assumption tested is normal distribution of the dependent variables, such as counting and number concept (one-to-one correspondence (OTOC), cardinality(C), and stable order (SO), number identification (NI) and quantity discrimination(QD)), and arithmetic (Dot Addition, Symbolic Addition, Dot Subtraction, and Symbolic Subtraction), and early mathematics motivation. Normal distribution is tested through the use of both statistical and graphical tests. For graphical analysis, box and whisker plots and normal probability plots for each dependent variable were examined. Box and whisker plots show groupings of data around specific values. The normal probability plots show the actual values compared to a theoretically normal distribution curve. In addition, the skewness and kurtosis of the data were examined. Skewness is an indication of how many of the observations fall disproportionately to the right (negative skewness) or left (positive skewness) of the distribution. Kurtosis is a measure of the peak (concentration) of the distribution. Statistically, to further evaluate the normal distribution, a statistical test was also evaluated using the Kolmogorov-Smirnov (K-S) statistic.

The **third** assumption to be tested for the dependent variables is constant variance of the dependent variable at all levels of the independent variables as well as to test the equality of covariance among the dependent variables across groups. The data are described as homoscedastic if the variance of the dependent variable is constant at all levels of the independent variables. If there is not constant variance, the data are described as heteroscedastic. To test the data for constant variance among the different levels of the independent variables, a Levene's test for constant variance was performed for each dependent variable. Box's M Test of Equality of Covariance Matrices that tested equality of covariance matrices of the dependent variables across control , experimental group one, experimental group two were enacted.

Elimination Outliers is the **fourth** assumption, outliers are extreme data points that may not be representative of the data population and may result in spurious outcomes if retained in the data set. While MANCOVA or ANCOVA is robust, it is appropriate to test the data for outliers and to examine any outliers for significant influence on the MANCOVA or ANCOVA results. To test for influential observations, each dependent variable was examined to determine if any of the observations qualified as an outlier by calculating mahalanobis distances using the regression menu (Tabachnick & Fidell 2012). The mahalanobis distance of each student was found but to decide whether a case is an outlier, the Mahalanobis distance value was compared against the alpha value of 0.001 (this is obtained using a chi-square taking the ten variables (five pretests and five posttests) as a degree of freedom (df).

The fifth is the linearity assumption means that there is a linear relationship between the set of the independent variables and the dependent variable. This assumption was assessed through plot the regression standardized residuals and the dependent variable (math scores) as described in the result section.

Therefore, in face of the assumption violation, utilizing Pillai's Trace test is the appropriate one and which is the most robust of the multivariate tests. In this study , there is small sample size, unequal N values, violation of assumptions, and then Pillai's trace is more robust. (Tabachnick & Fidell, 2012).

VI) Pearson Correlations was used to find out strengths of relationship between predictors and criterion variables. The correct method of conducting correlation analysis in repeated measures design has not been rigorously described till date (Srinivas & Chakrabarti, 2017).

The potential method includes demonstrating a variety of ways to analyze these data, using both simple regression/correlation and rmcorr, involving separate simple regression/ correlations, repeated measure correlation (rmcorr), and simple regression/correlation using averaged data. For this study that last one was chosen since averaging the repeated measures data (pretest and posttest) for each participant prior to performing the correlation may resolve the issue of non-independence but can produce misleading results if there are meaningful individual differences (Myung et al., 2000).

The researcher adopted the interpretation of prediction aimed correlation values by Cohen et al. (2000). Cohen and his colleagues forwarded the following basic suggestions:

a. correlation coefficients from 0.20 to 0.35 are very slight relationship; magnitudes in this range portray limited value.
b. correlation values within the range from .35 to .65 usually show very limited accuracy in prediction. Pearson r values nearly 0.40 may be helpful for group, not for individual predictions. However, correlation values within this range can produce useful meaning if they are combined multiple regression analysis.
c. correlation coefficients between 0.65 to 0 .85 are accurate enough for group predictions applicable for different purposes. Near the top and above correlation values also contribute a lot to individual predictions.

Identifying the extent of shared variances (or relationships) between paired sub-tests (indicators) was the focus of the Pearson r analysis. While the Pearson r was applied to find out the magnitudes of relationships, corresponding coefficients of determination were computed to analyze how much shared variance exists between paired variables. The zero-order or bivariate linear correlations within and between the subtests of the three constructs - CNC, arithmetic and early mathematics motivation -without controlling the effect of any other variable that might affect the relationships were applied. For getting more clarity, the Pearson r's can be categorized into groups of five: four within each of the procedural counting, conceptual counting, number concept and arithmetic constructs, and one between the constructs. The Inter-correlation among subscales of early mathematics motivation was done using Pearson moment product. The relationship among intrinsic motivation (IM), identified regulation (IR) and controlled regulation (CR) are measured under two constructs CNC motivation and arithmetic motivation.

VII) Multiple regression techniques was used to determine the predictive values of selected independent variables on the dependent variables. Multiple regression is used with ratio or interval variables. Multiple regression combines variables that are known individually to predict (i.e., correlate with) the criterion into a prediction equation. Multiple regression is an extremely valuable procedure for analyzing the results of a variety of experimental, causal–comparative, and correlational studies because it determines not only whether variables are related but also the degree to which they are related. Understanding how variables are related is beneficial both for researchers and for groups needing to make data-based decisions (Suárez-Álvarez, 2014).

In this study, by performing multiple regressions, the role of counting and addition as predictor of subtraction was evaluated. The enter method was applied in procedure of multiple regression analysis, because it was the most appropriate way to determine the association between all variables, whether they are significant or not. It is separately predicted subtraction performance in two domains (dot and symbolic). The hierarchical regressions were performed with domain of subtraction (dot and symbolic), as dependent variables. In each regression analysis, the focused CNC measure (procedural counting, conceptual counting and number concept) was entered in the first step and addition (dot and symbolic) in the second.

In doing so, various assumptions of parametric data analysis were checked against the research data just to be safe while interpreting findings.

- **i.** The data generated through tests was in a ratio or interval scale
- **ii.** Sufficient number of samples
- **iii.** The test results were individual responses and hence no threat for response interdependence;
- **iv.** The data distribution was normal as checked in preliminary results using the normal curve.
- **v.** Whether the extent of variation is similar across the groups, given that the sample selection was random, the sample size was enough, and the context of education in Addis Ababa has more similarities (home, language, medium of instruction, education management, government owned schools, etc.) than differences, the researcher assumed equality of variances in the set of data. It should also be noted that in large sample sizes, Levene's test for equality of variances may show significant variation differences even if the group difference, in reality, is so minimal (Field, 2013).

vi. Multi-collinearity and singularity**,** this refers to the relationship among the independent variables. Multicollinearity exists when the independent variables are highly correlated (r= 0.9 and above). Singularity occurs when one independent variable is actually a combination of other independent variables (e.g. when both subscale scores and the total score of a scale are included). Multiple regressions don't like multi-collinearity or singularity and these certainly don't contribute to a good regression model, so always check for these problems before start.

vii. Normality, linearity, homoscedasticity, and independence of residuals, these all refer to various aspects of the distribution of scores and the nature of the underlying relationship between the variables. These assumptions can be checked from the residuals scatter plots which are generated as part of the multiple regression procedure. The differences between the obtained and the predicted dependent variable (DV) scores are residuals. The residuals scatter plots allow to check:

a. Normality: there should be a normal distribution by residuals about the predicted DV scores.
b. Linearity: there should be a straight-line relationship between the residuals and predicted DV scores
c. Homoscedasticity: for all predicted scores**,** the variance of the residuals about predicted DV scores should be the unchanged.

In summary, the violation of all assumptions can be check using various ways. These are, *in the first assumption, Ratio or Interval Scale***,** it is apparent that for regression analysis all the variables whether independent or dependent are continuous. Variables in the CNC, arithmetic, and early mathematics motivation domains were ratio, ratio, and interval scale respectively. *Secondly, sample size***,** different authors give different guidelines concerning the number of cases required for multiple regressions. Stevens (1996) recommends that 'for social science research, about 15 participants per predictor are needed for a reliable equation. Tabachnick and Fidell (2012) give a formula for calculating sample size requirements, taking into account the number of independent variables that you wish to use: $N \geq 50 + 8m$ (where m = number of independent variables). If you have five independent variables, you will need 90 cases. In this dissertation study, the number of participants in each independent variable was 72. More cases are needed if the dependent variable is skewed. For stepwise regression, there should be a ratio of 40 cases for every independent variable. The third assumption tested is the *independence of observations* of the dependent variable, which had similarity with the assumption stated in MANCOVA. Fourthly, *Multi-collinearity and singularity,* with respect to correlations, this assumption to be achieved, in the first place, the independent variable CNC (procedural counting, conceptual counting, and number concept) and addition (dot and symbolic) show at least some relationship with dependent variable in this case dot subtraction (above 0.3 preferably). For the part of the multiple regression procedure, 'collinearity diagnostics' indicates whether there were problems with multi-collinearity or not. So, tolerance and VIF (Variance inflation factor) have to be more than 0.1 and less than 10, respectively. If so, the multi-collinearity assumptions were not violated. Lastly, *Outliers, normality, linearity, residuals homoscedasticity, and independence of residuals*, by inspecting the Normal Probability Plot (P-P) of the Regression Standardized Residual and the Scatter-plot, one of the ways that these assumptions can be checked through. In the Normal P-P Plot, the data points lie in a reasonably straight diagonal line from bottom left to top right. In the Scatter plot of the standardized residuals, most of the scores have to be concentrated in the centre (along the 0 point). Deviations from a centralized point suggest some violation of the assumptions. By inspecting the Mahalanobis distances the presence of outliers can be detected. Alternatively, it is also possible to check using Scatterplot. Tabachnick and Fidell (2012) define outliers as cases that have a standardized residual (as displayed in the scatter plot) of more than 3.3 or less than –3.3.

VIII) Canonical Correlation Analysis (CCA) is a multivariate statistical model that facilitates the study of linear interrelationships between two sets of variables: one set of variables is referred to as independent and the other as dependent; a composite score is formed for each set (Mills & Gay, 2019). CCA develops a canonical function that maximizes the correlation between the two composite variables. The loadings of the individual variables differ in each canonical function and represent variables' contributions to the specific relationship being investigated. Now, the challenge is to choose how many of them should be interpreted, however, in most cases the first function is the most legitimate (Hair et al.,1998). To determine the relative importance of each original variable into each function, three methods have been proposed (i) canonical weights (standardized coefficients), (ii) canonical loadings (structural correlations) and (iii) canonical cross-loadings. Most of the literatures suggest to use canonical loadings or crossing loadings (Liu et al., 2009). Both loadings were used, however, there is no established cut off. There is a rule of thumb if any variable loading is |0.30| then it can be considered to be an important contributing variable into the function (Lambert & Durand, 1975). The score plot, 1st variate on the horizontal axis and the 2nd variate on the vertical axis, of composite score also helped to find natural variable groupings into the data set (Gonza'lez, et al., 2008).

3.10. Ethical Issues

Taking into account the ethical issues is enormously significant in experimental works. In experimental research, assuring confidentiality and anonymity in reporting the information gathered in order to maintain the integrity of the institutions concerned, seeking informed consent were needed to be ethically considered.

Confidentiality

Confidentiality was first respected by gleaning all information collected from the participants of the research. The early mathematics motivation rating scale scores and the early numeral achievement scores are maintained in confidentiality. The individual or schools name was not referred in the data, rather, all data were treated with codes and combined with others. This was done for the sake of keeping the participants with MD from unnecessary harm, psychological and social harm. The participants' psychological wellbeing should be cared, not feel stressed, embarrassed, depressed, anxious, or fearful.

Informed Consent

The interventionists and mathematics teachers were informed about the general objective of the research, the intervention protocols, what the experiment involves and they were aware of their rights while participating in all sessions. These include, if they were frighten or even merely bored, they have the right to withdraw from the study at any time. On account of entailing too young children to understand what was going on in the intervention processes is very difficult, informed consent was disclosed to their parents and permission was obtained from parents or caregivers. Despite getting permission for their child participation on experiments, ultimately the child has the right to withdraw from the study at anytime, and their wishes must certainly be respected. Parents or caregivers and any others were promised to access the final version research results as long as they are interested. They participated only voluntarily, without any pressure or influence. Overall, deception was totally avoided in this study.

Debriefing

Taking into consideration the MLC program of the schools, BANUCA were utilized for discerning students having MD with or without reading difficulties. The outcome of BANUCA was debriefed for the schools administrators, mathematics teachers and parents. Upon completion of the instructional intervention experiments, the pertinent outcomes were revealed to teachers and the school administrators.

Generally, the utmost possible ethical roles have been considered ensuring ethically, maintaining consent, anonymity, dignity, and procedural rigor of the research conducted.

Chapter Four
Results

4.1. Introduction

This finding section is organized based on experimental and correlational results. The presentation, firstly, deals with the status of demographic variable**,** group equivalence in terms of for CNC, arithmetic achievement and early mathematics motivation, and the preliminary analyses on the statistical assumptions required for the statistical method to be valid. The second part focuses on the effect of concrete fading instruction using gabat'a on CNC and./or arithmetic achievement and early mathematics motivation. Thirdly, prediction on early grade CNC and arithmetic achievement by early mathematics motivation is dealt.

4.2. The Status of Demographic Variables and Pretest Group Equivalence

4.2.1. Demographic Variables and Pretest group Equivalence for CNC

Age, sex, difficulty type, PMK, and first language status are the key demographic characteristics of students were examined. Under Table 13, the demographic information of the participants with MD by conditions and session time (pretest and posttest) are portrayed.

Table 13

The Demographic Information of the Participants with MD by Conditions and Time for CNC

Variables	Conditions			
	Pretest		Posttest	
	CIGO n (36)	Control group n (36)	CIGO n (35)	Control group n (36)
Gender				
M	41.7%	47.22%	42.86%	47.22%
F	58.3%	52.78%	57.14%	52.78%
Age in years (mean)	8.25	7.78	7.94	7.78
Difficulty types				
MD	44.44 %	50 %	41.67 %	50 %
MDRD	45.56 %	50 %	58.33 %	50 %
Prior Experience				
Yes	61.11 %	55.56%	58.33 %	55.56%
No	38.89%	44.44%	41.67 %	44.44%
First language status				
Amharic	52.78 %	58.33%	54.28 %	58.33%
Others	47.22 %	41.67%	45.72 %	41.67%

In pretest, there were 36 students in each condition but 35 students were available in CIGO group for post-testing. The average age of the students in the CIGO group was 8.25 years and in control group was 7.78 years as well. The first graders with MD in the study were diverse in gender, with 41.7% male in CIGO and 47.22% male in control group. The difficulty types of the sample, as determined by the percentage of MD students 44.44 % in CIGO and 50% in control group. In addition, 61.11 % and 55.56% of the sample students with MD have PMK in CIGO, and control groups, respectively. The language status breakdown was revealed as follows: 52.78 % for CIGO and 58.33% for control group of students speak Amharic as their first language. Ultimately, during post-testing, the demographic data were the same as the pretesting as far as the pretesting concerned, but one student was missing in CIGO group, so male 42.86%, age 7.94, MD 41.67%, PMK 58.33%, and Amharic as first language 54.28%.

The pretest group equivalency in terms of size across demographic subgroups and other factors was also examined to distinguish the possible group differences (see Table 14). Independent samples t-tests and chi-square analyses was used to evaluate differences between conditions. It showed that no significant differences (*p*>.05) on any of the demographical characteristics (e.g., age, gender, difficulty type, PMK, and language status) and expressly gender *(χ^2 =0.113, P=0.94)*, children's mean age (t = 1.09, P=0.256), difficulty types (χ^2 =0.503, P=0.32), PMK *(*χ^2 =0.23, P=0.41*)*, and language status (χ^2 =0.225, P=0.41*)* as depicted in Table 14.

Table 14

Pretest Comparison across Key Demographic Variables and Conditions for CNC

Groups	Description	CIGO	Control group	Group differences
Age	Mean (SD)	8.25 (1.95)	7.78(1.725)	t = 1.09, P=0.256
Gender	Percentages of boys	41.7%	47.22%	χ^2 =0.225, P=0.41
Difficulty types	Percentages of Students with MD	44.44 %	50 %	χ^2 =0.503, P=0.32
Prior knowledge	Percentages of students' PMK	61.11 %	55.56%	χ^2 =0.23, P=0.41
Language status	Percentages of students who speak Amharic	52.78 %	58.33%	χ^2 =0.225, P=0.41

Note: P< 0.05

4.2.2. Demographic Variables and Pretest group Equivalence for Arithmetic

The key demographic characteristics of students were examined, including age, sex, difficulty type, PMK, and first language status. Then, the demographic information of the participants with MD by conditions and session time (pretest and posttest) are portrayed under Table 15. In pretest, there were 24 students in each condition but in the posttest the same number as pretest except 23 in AIGO group. The average age of the students in the AIGG group was 8.3 years, in the AIGO group was 7.8 years, and in control group was 8.0 years as well. The first graders with MD in the study were diverse in gender, with 41.7%

male in AIGG, 45.8% male in AIGO group and 45.8% male in control group. The difficulty type of the sample, as determined by the percentage of MD students 45.8% in AIGG, 45.83% in AIGO and 50% in control group. In addition, 41.7 %, 45.8 %, 50% of the sample students with MD have PMK in AIGG, AIGO, and control group, respectively. Concerning, the language status breakdown was revealed as follows: 54.2%, 58.3%, and 54.2% of students speak Amharic as their first language. The post-testing demographic data is similar with the pretesting except missing one student in AIGO group.

Table 15

The Demographic Information of the Participants with MD by Conditions and Time for Arithmetic

Variables	Conditions					
	Pretest			Posttest		
	AIGG n (24)	AIGO n (24)	CG n (24)	AIGG n (24)	AIGO n (23)	CG n (24)
Gender						
M	41.7%	45.8%	45.8%	41.7%	43.5%	45.8%
F	58.3%	54.2%	54.2%	58.3%	46.5%	54.2%
Age in years (mean)	8.25	7.79	8.00	8.25	7.78	8.00
Difficulty types						
MD	41.7%	45.8 %	50 %	45.3 %	43.5 %	50 %
MDRD	58.3%	54.2 %	50 %	44.8%	46.5 %	50 %
Prior Experience						
Yes	41.7 %	45.8%	50.0%	41.7 %	43.5 %	50.0%
No	58.3 %	54.2%	50.0%	58.3 %	56.5 %	50.0%
First language status						
Amharic	54.2 %	58.3%	54.2%	54.2 %	60.9%	54.2%
Others	45.8 %	41.7%	45.8%	45.8 %	39.1%	45.8%

Note: CG = control group

It was also examined the data for possible differences on the pretest group equivalency in terms of size across demographic subgroups and other factors (see Table 16). A chi-square test of independence indicates there was no significant difference in the proportion of pretest group equivalency across all subgroups. Specifically, regarding gender, males were no significantly different from females on all pretest group equivalency (χ^2 =0.11, P=0.94). Similarly, no significant differences among three groups were found at pretest evaluation in terms of children’s mean age (F=0.37, p=0.69), difficulty types (χ^2 =0.34, P=0.84), PMK (χ^2 =0.34, P=0.84), and language status (χ^2 =0.11, P=0.94) as reported in Table 16.

Table 16

Pretest Comparison Across Groups for arithmetic

Groups	Description	Experimental One	Experimental Two	Control	Group differences
Age	Mean (SD)	8.25 (1.82)	7.79 (2.02)	8.00(1.72)	F= 0.37, P=0.69
Gender	% of boys	41.7%	45.8%	45.8%	$\chi2$ =0.11, P=0.94
difficulty types	Percentages of Students with MD	41.7 %	45.8%	50.0%	$\chi2$ =0.34, P=0.84
Prior knowledge	Percentages of Students having KG experience	41.7 %	45.8%	50.0%	$\chi2$ =0.34, P=0.84
Language status	% of Students speak Amharic	54.2 %	58.3%	54.2%	$\chi2$ =0.11, P=0.94

Note: P<0.05

4.3. Effect of Concrete Fading Intervention Using Gabat'a on CNC and early mathematics motivation

4.3.1. Preliminary Analyses

Two key prerequisites, ahead of performing MANCOVA, are the assumptions of homogeneity of variance and homogeneity of covariance matrices analysis to test the influence of concrete fading instructional strategy using *gabat'a* on CNC achievement and early mathematics motivation, the dependent variables must be analyzed to determine if they satisfy the statistical assumptions required for the statistical method to be valid.

In Table 17, MANCOVA results indicated that the assumption of equality of covariance among the dependent variables across groups was acceptable because Box's M Test of Equality of Covariance Matrices that tested equality of covariance matrices of the dependent variables across experimental group and control group was significant, F (136,14677.64) = 3.40, p =0.000 (See Table 17), where as to test the data for constant variance among the different levels of the independent variables, a Levene's test for constant variance was performed for each dependent variable. The results of the tests for constant variance for each dependent variable (post-test values) are now discussed and summarized in Table 18. As can be seen in this table, the levene's tests of most of the posttesting measure were significant while all of the pretesting measure were not.

Table 17

Box's Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.
613.888	3.40	136	14677.643	0.000

Note. P<0.05

Table 18

Levene's Test of Equality of Error Variances

Measures	F	df1	df2	Sig.
Pretest C	.093	1	69	.76
Posttest C	50.390	1	69	.00
Pretest OTOC	.025	1	69	.87
Posttest OTOC	57.496	1	69	.00
Pretest SO	.057	1	69	.81
Posttest SO	9.498	1	69	.003
Pretest NI	.160	1	69	.69
Posttest NI	1.442	1	69	.23
Pretest QD	.381	1	69	.54
Posttest QD	7.437	1	69	.008
Pretest EMM	.484	1	69	.49
Posttest EMM	1.829	1	69	.18

Note. P<0.05; OTOC =one-to-one correspondence;C=cardinality; SO=stable order, NI= number identification; QD=quantity discrimination; & EMM=early mathematics motivation

The Levene's tests for each measure during pretesting, cardinality (groups: F(1,69)=.093, p=0.76), OTOC (groups: F(1,69)= 0.025, p=.87), SO (groups: F=0.057, p=0.81), NI (groups: F=0.160, p=0.69), QD (groups: F=0.381, p=0.54) and early mathematics motivation (groups: F(1,69)=0.484, p=0.49). Besides, the Levene's tests of measures during post-testing, cardinality (groups: F(1,69)=50.349, p=0.000), OTOC (groups: F(1,69)=57.50, p=0.000), stable order (groups: F(1,69)= 9.5, p=0.003), NI (groups: F(1,69)=1.44, p=.23), quantity discrimination F(1,69)=0.057, p=0.81) and early mathematics motivation (groups: F(1,69)=1.83, p=0.18).

Therefore, other assumptions were not checked since the key assumptions of homogeneity of variance and homogeneity of covariance matrices were not met, as Levene's Test of homogeneity for most of the post-testing measures and Box's M were significant (p < 0.05), pointing out that the assumption was violated. In face of the assumption violation, small sample size, unequal N values, and then utilizing Pillai's trace is more robust for the multivariate tests (Tabachnick &Fidell, 2012).

Secondly, equivalence of groups in terms of pretest measures, before conducting the experiment, was made. Independent one way MANOVA was used to evaluate preexisting differences among subgroups on the pretest measures CNC. The two groups, the CIGO and control group, did not differ in terms CNC (such as, C, OTOC, SO, QD and early mathematics motivation), none of the variables resulted in significant differences (*p* > 0.05), suggesting that they came from the same population. Specifically, Table 19 shows the two groups descriptive and inferential statistics on CNC achievement, revealing the non-significant result of C, p = 1.00; OTOC, p = 0.40; SO, p = 0.96; QD, p = 0.74; and early mathematics motivation, p=0.36).

Table 19
Test of One Way MANOVA of CNC Pretest Results

Groups	Counting and number concept				
	C	OTOC	SO	QD	EMM
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
With CIGO	4.83(2.77)	23.50(8.70)	10.08(7.67)	4.42(3.68)	39.00 (13.63)
Control group	4.83(2.62)	25.14(7.60)	10.00(7.74)	4.14(3.42)	35.86 (15.16)
Sum of Squares	.000	48.35	.125	1.39	177.35
F	.000	725	.002	.110	.853
P	1.00	0.40	0 .96	0.74	0.36

Note. P>0.05; OTOC =one-to-one correspondence;C=cardinality; SO=stable order, NI= number identification; QD=quantity discrimination; & EMM=early mathematics motivation

4.3.2. Main Findings on CNC

The results are presented based on the experimental one - research hypotheses. All the hypothesis of this section, that is, the effect of concrete fading instructional strategy using gabat'a on CNC achievement, early mathematics motivation, as well as the individual differences (i.e., gender, difficulty type, and PMK) in terms of CNC achievement and early mathematics motivation of the participants with MD all together were run utilizing General Linear Modeling (GLM) of Multivariate Analysis of Covariance (MANCOVA) via taking individual differences as covariates. The covariates in the models were used to reduce the error variance and increase the statistical power. Hence, the 3x2 mixed MANCOVAs was organized to test for main effects of experimental conditions (CIGO versus control group) as a between-subjects variable on CNC achievement and early mathematics motivation and time (pretest, posttest) as within-participant factors as well as to test for interaction effects.

The mean CNC test scores with SD as a function of group membership and time was gauged. These descriptive statistics were placed for pretest, post-test of cardinality, one to one correspondence, stable order, quantity discrimination and early mathematics motivation alongside the control and experimental groups separately. From Table 20, it can be seen that the scores for CIGO experimental group improved from the pretest to the posttest, while the scores for the control group improved less than the CIGO groups. Further analysis was made using inferential statistics for general interpretation.

Table 20

Mean of CNC Achievement and Early Mathematics Motivation Scores with SD

Measures	Components	Groups	Pretest Mean(SD)	Posttest Mean(SD)
CNC achievement	Cardinality (C)	With CIGO	4.83(2.77)	8.80 (473)
		Control	4.83(2.62)	6.64(2.37)
	One to one Correspondence (OTOC)	With CIGO	23.50(8.70)	29.69(.99)
		Control	25.14(7.60)	23.39 (7.18)
	Stable order (SO)	With CIGO	10.08(7.67)	16.89(3.98)
		Control	10.00(7.74)	10.67(6.03)
	Quantity Discrimination (QD)	With CIGO	4.42(3.68)	8.86(2.02)
		Control	4.14(3.42)	6.44 (2.85)
EMM	Early mathematics Motivation (EMM)	With CIGO	39.00 (13.63)	51.80 (9.70)
		Control	35.86 (15.16)	41.19 (13.51).

Overall, the MANCOVA via controlling the effects of individual differences (i.e., gender, difficulty type, and PMK as covariates) was used to reduce the error variance and increase the statistical power. It revealed a significant main effect for group with ($p<0.000$), depicting in Table 21 that Pillai's Trace test of 0.46 was significant, [$F(9,56) = 5.36$, $\eta^2 = 0.46$] and rejected the hypotheses that population means on the dependents were the same for control and treatment group. indicating that the concrete fading instruction strategy using gabat'a enhance CNC achievement and early mathematics motivation of students with MD. Additionally, the main effect of time was performed utilizing MANCOVA, the value for Pillai's trace for time (pretest and posttest) was 0.10 with $F(9,56)= 70.10$, $P< 00$, $\eta^2 = .10$, indicating that there was a change in scores of in all CNC components and early mathematics motivation across the two different time periods. In addition, the two way interaction effect between Group x Time interaction was significant, Pillai's Trace = 0.59, $F(9, 56)= 8.88$, $p= 0.00$, partial $\eta^2= .59$ (see Table 21), showing that the scores for groups improved from the pretest to the posttest, but that the scores for the experimental group improved significantly more than the scores for control groups.

Table 21

The MANCOVA for CNC Achievement and Early Mathematics Motivation as a Function of Group, Time and Interaction between Condition and Time

Effect	Pillai's trace Value	F	Hypothesis df	Error df	Sig.	Partial η^2	Noncent. Parameter	Observed Power
Groups	0.46	5.36	9.00	56.00	0.00	0.46	48.27	.10
Time	0.10	70.10	9.00	56.00	0.00	0.10	21943.34	1.00
Time*Group	.59	8.88	9.00	56.00	0.00	.59	79.10	1.00

Note. Computed using alpha = 0.05

If both main and interaction effects found to be significant, pair-wise comparison analyses would be highly compatible than posthoc comparison analysis to determine where the significant differences lie, the comparisons analyses were done as part of MANCOVA output to compare the achievement of CNC domains and early mathematics motivation across groups from CIGO to control. The CIGO group exhibited a typical significant superiority in all domains on CNC achievement (C, p=0.04; OTOC, p=0.04; SO, p=0.03; and QD, p=0.055) and EMM (p=0.056) than control group; except a marginal significant is registered for QD and EMM (see Table 22). A marginal significant means still the finding could have a real effect(Olsson-collentine et al., 2019), indicating teaching quantity discrimination using concrete fading instruction made the students with MD to be motivated.

Table 22

Pair-wise Comparisons of Groups from CIGO to Control Group (CG)

Measure	Mean Difference from CIGO to CG	Std. Error	Sig.	95% Confidence Interval[b] Lower Bound	Upper Bound
C	.96**	.45	.04	.05	1.87
OTOC	2.54**	1.20	.04	.13	4.94
SO	3.04**	1.40	.03	.237	5.847
QD	1.271*	.650	.055	-.028	2.569
EMM	5.923*	3.047	.056	-.164	12.010

Note. ** The mean difference is significant at the .05 level; * The mean difference is marginally significant; One-to-one correspondence =OTOC; Cardinality=C ; Stable order (SO), Number identification=NI; and quantity discrimination=QD; and early mathematics motivation=EMM

Additionally, a pair-wise comparison as part of MANCOVA output was conducted to further investigate the domains of CNC achievement and early mathematics motivation across the pretest to posttest. From this, the result indicated that the participants with MD exhibited a significant gains from the pretest to the posttest in all domains of CNC achievement and early mathematics motivation, namely cardinality, one to one correspondence, stable order, quantity discrimination and early mathematics motivation, all at p<0.05 (see Table 23).

Table 23

Pair-wise Comparisons from Pre- to Post-test data of CNC Achievement and Early Mathematics Motivation Scores

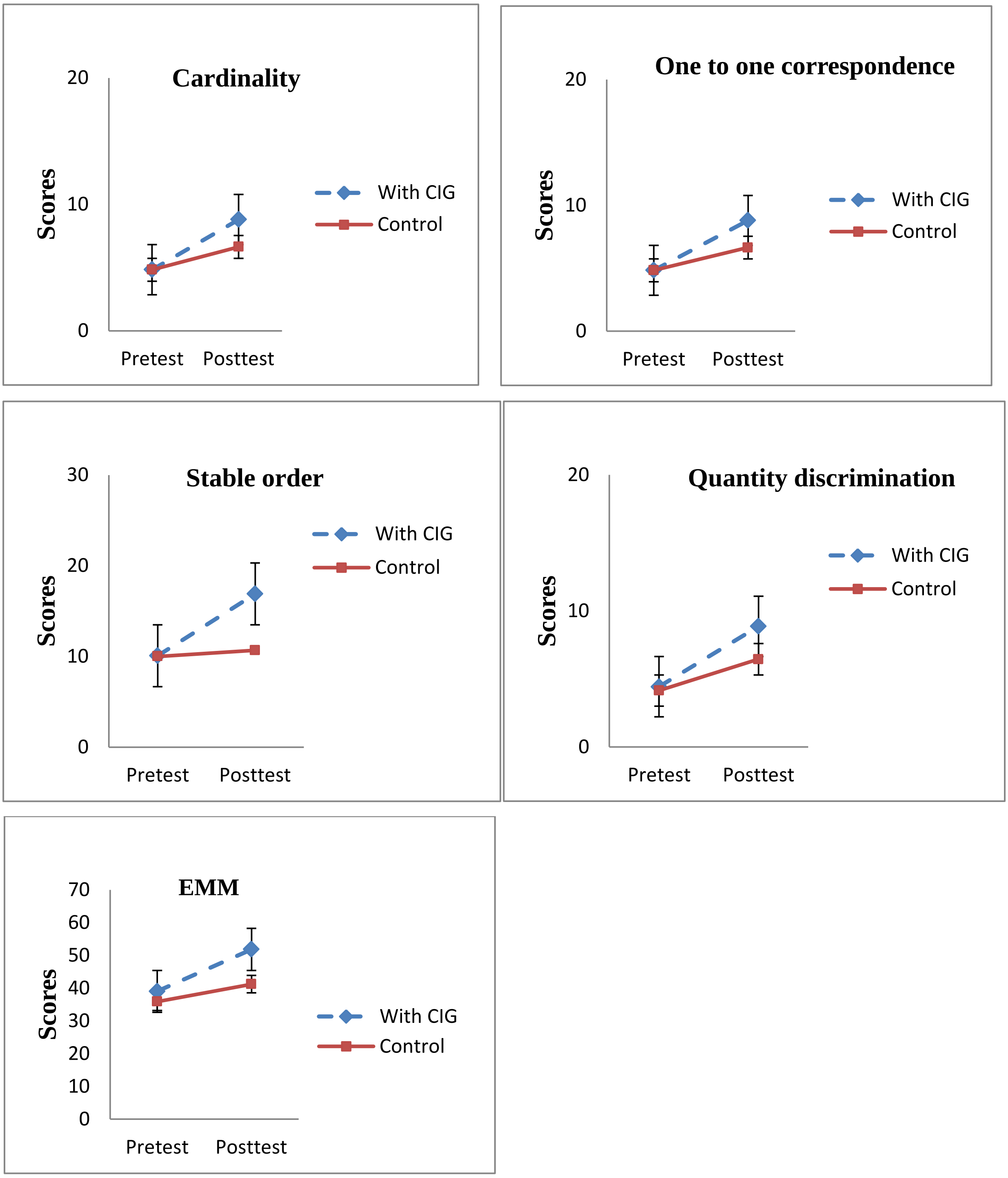
Measure	Mean Difference from pre-to posttest	Std. Error	Sig	95% Confidence Interval for Difference Lower Bound	Upper Bound
C	-2.90*	.27	.000	-3.453	-2.355
OTOC	-2.31*	.82	.006	-3.942	-.681
SO	-3.76*	.68	.000	-5.133	-2.395
QD	-3.42*	.33	.000	-4.079	-2.770
EMM	-9.37*	.64	.000	-10.644	-8.092

Note. The mean difference is significant at the .05 level

Figure 10 shows the mean CNC achievement scores of C, OTOC, SO, QD, and early mathematics motivation as a function of group membership and time. From this Figure 10, it can be seen that the scores of the CIGO experimental group improved from the pretest to the posttest more than the scores for the control group in each categories.

Figure 10

CNC and Early Mathematics Motivation Scores as a Function of Group and Time



Individual Differences in CNC Achievement and Early Mathematics Motivation Scores. The third hypothesis stated that the effect of concrete fading instruction using gabat'a for students with MD did not show a significant difference in gender, difficulty type, and PMK. To test this hypothesis, a mixed MANCOVA was conducted, considering CNC achievement and early mathematics motivation as dependent variables; and groups, gender, time, difficulty type, and PMK, as independent variables.

Gender Differences in CNC Achievement and Early Mathematics Motivation Scores. The Mixed MANCOVA indicated that, there is no significant difference on the main effect of gender on CNC achievement and EMM. As depicted in Table 24 , the Pillai's Trace of 0.14 was not significant, F(9, 45)= 0.84, p >.05, and failed to reject the hypothesis that population means on the dependent variables were the same for male and female students with MD. However, three way interactions among Groups, Gender, and Time were not significant (Pillai's Trace = .09,F(9,45)= 0.49, partial η^2= 0.09, p > .05 for all interactions) and also the two way interaction between gender and groups, the Pillai's Trace of 0.15, F(9,45)=0.87, p >.05 (see Table 24) and between gender and time, Pillai's Trace of 0.17, F(9,45)=1.00, p >.05 were not significant. As a whole, the results indicated that there were no significant difference in CNC achievement and early mathematics motivation between male and female students with MD in experimental and control group and from pretest to posttest as well.

Table 24
Mixed Multivariate Tests of Gender

Effect	Pillai's Trace Value	F	Hypothesis df	Error df	Sig.	Partial η2	Noncent. Parameter	Observed Power
G	0.14	0.84	9.000	45.00	.585	.144	7.544	.36
G * Gp	0.15	0.87	9.000	45.00	.557	.148	7.839	.372
G * T	0.17	1.01	9.000	45.00	.451	.167	9.041	.430
G* T * Gp	0.09	0.49	9.000	45.00	.874	.089	4.399	.209

Note. Computed using alpha = 0.05; G=gender; Gp=group; and T=time

CNC achievement and Early Mathematics Motivation Scores as a Function of Difficulty Types. As shown in Table 25, the mixed multivariate tests indicated no significant interaction effect between the session time and difficulty type (Pillai'sTrace = 0.28, F(9,45) = 1.98, p > .05, partial η^2 = 0.284) on either CNC achievement and early mathematics motivation. There was no evidence indicating a significant three way interaction among Gp * T * difficulty type (Pillai's Trace = .07, F = .38, p > .05 partial η^2 = .07). Besides, there were no indications of the main effects of difficulty type, Pillai'sTrace = .13, F(9,45) = 0.72, p > .05, partial η^2 = 0.13. A marginal significant interaction effect between groups and difficulty type was registered, Pillai's Trace =0 .06, $F(9,45) = 0.31$, $p < 0.05$, partial $\eta^2 = 0.06$. Totally, the findings indicated that there was no difference between MD and MDRD in terms of experimental and control groups, pretest and posttest scores, and gender.

Table 25
Multivariate Effect of Difficulty Type

Effect		Pillai's Value	F	Hypothesis df	Error df	Sig.	Partial η^2	Noncent. Parameter	Observed Power
Between Subject	DT	0.13	.72	9.00	45.000	.686	.13	6.497	.307
	Gp * DT	0.06	.31	9.00	45.000	.966	.06	2.839	.143
Within Subject	DT * T	0.28	1.98	9.00	45.000	.064	.284	17.849	.777
	DT * Gp * T	0.07	.38	9.00	45.000	.940	.070	3.390	.165

Note: Computed using alpha = .05; Gp= groups; T= time, and DT=difficulty type

CNC Achievement and Early Mathematics Motivation Scores as a Function of Prior Knowledge. CNC achievement and EMM scores as a function of PMK are shown in Table 26. The question of whether the main and interaction effect of experimental conditions (CIGO versus control group) have influence across PMK of students with MD was answered by conducting between and within subject MANCOVA design. All the main effect and interaction were not significant. Specifically, the Pillai's Trace was not significant for main effect of PMK [Pillai's Trace = .22, $F(9,45) = 1.38$, $p > .05$, partial $\eta^2 = .22$]. No significant experimental conditions * PMK interaction [Pillai's Trace = .065, $F(9,45) = .35$, $p < .05$, partial $\eta^2 = .065$] or session time * PMK [Pillai's Trace = .16, $F(9,45) = .95$, $p > .05$, partial $\eta^2 = .16$] was found. Moreover, the interaction among Groups * Time * PMK revealed that there was not a significant interaction among them, Pillai's Trace = .13, $F(9,45) = .718$, $p > .05$, partial $\eta^2 = .13$). Entirely, the results indicated that there was no difference in CNC achievement and early mathematics motivation between students having PMK and those who have not, in terms of experimental and control group, from pretest to posttest and gender wise as well.

Table 26
Multivariate Effect of Prior Mathematics Knowledge

Effect	Pillai's Value	F	Hypothesis df	Error df	Sig.	Partial η2	Noncent. Parameter	Observed Power
PMK	0.22	1.38	9.000	45.000	.226	.22	12.418	.584
PMK * Gp	.065	.35	9.000	45.000	.952	.065	3.148	.156
PMK * T	.16	.95	9.000	45.000	.494	.16	8.531	.406
PMK * T *Gp	.13	.718	9.000	45.000	.690	.13	6.460	.305

Note: Computed at p=0.05; Gp= groups; T= time, and PMK= prior mathematics knowledge

To recap, the key findings of this study demonstrated the concrete fading CNC instruction using gabat'a has a significant effect on each component of CNC achievement and early mathematics motivation. However, the other main and interaction effect findings are inconsistence. Detail discussion of each outcome will be done in the next section.

4.4. The Effect of Concrete Fading Intervention Using Gabat'a on Arithmetic Achievement and Early Mathematics Motivation

4.4.1. Preliminary Analyses

Before conducting the MANCOVA , the basic statistical assumptions were checked. The individual panels of the MANCOVA analysis identified addition (dot and symbolic) and subtraction (dot and symbolic), and early mathematics motivation as dependent variables that were significantly affected by either the main effect of the intervention or the interaction between them. These dependent variables were subjected to subsequent individual univariate analysis, for some cases. Dot addition, symbolic addition, dot subtraction, symbolic subtraction, and early mathematics motivation were initially analyzed using MANCOVA to determine the overall significance of the model. Subsequently, dot addition, symbolic addition, dot subtraction and symbolic subtraction, and early mathematics motivation were analyzed using MANCOVA. In addition, a within-subject analysis was performed on the four dependent variables including one early mathematics motivation using repeated measures MANCOVA.

The statistical assumptions that were initially applied to the dependent variables were the multivariate assumptions of MANCOVA. The multivariate assumptions of MANCOVA are similar to the univariate assumptions of ANCOVA. The statistical assumptions details are unfolded as follows,

Independent Observations. The first assumption tested is the independence of observations of the dependent variable. Independence of observations is achieved through a between-subjects design to test differences with respect to experimental groups, gender, difficulty type and PMK; and random assignment of participants to each of the treatment groups by applying stratified randomized sampling design. In addition, each participant worked individually and performed the experimental task at one time. As a result, each of the observations is independent of all other observations for the dependent variables.

Normal Distribution. The second assumption tested was normal distribution of the dependent variables, such as, dot addition, symbolic addition, dot subtraction, symbolic subtraction and early mathematics motivation, and the statistical test was utilized to evaluate the normal distribution of Kolmogorov-Smirnov (K-S) statistic (see Table 27).

Table 27

Tests of Normality and Descriptive

	Kolmogorov-Smirnov[a]			Descriptive	
Time and number notation	Statistic	Df	Sig.	Skewness	Kurtosis
Pretest DA	.12	70	.014	-.530	-.26
Pretest SA	.12	70	.014	-.530	-.26
Pretest DS	.11	70	.051	-.46	-.16
Pretest SS	.12	70	.010	-.53	-.175
Pretest EMM	.09	70	.200*	-0.56	-0.36
Posttest DA	.225	70	.000	-1.16	0 .41
Posttest SA	.175	70	.000	-.93	-.02
Posttest DS	.17	70	.000	-.81	-.22
Posttest SS	.12	70	.017	-.63	-.26
Posttest EMM.	.12	70	.010	-0.66	-0.19

Note: Computed using alpha = .05; DA=dot addition; SA=symbolic addition; DS=dot subtraction; and SS=symbolic subtraction, and EMM=early mathematics motivation

For pretesting, dot addition exhibits skewness (-0.53) and kurtosis (-0.26) indicating slight negative departure from a normal distribution and a fairly normal peak respectively. This is supported by the K-S statistic (p=.014). Symbolic Addition exhibits a similar trend with dot addition (skewness=-0.53, kurtosis=-0.26), having a significant value of K-S statistic (p=0.014). Dot subtraction exhibits slight departure from normality negatively (skewness =-0.46) but with a moderate normal peak (kurtosis=-0.16), which is consistent with the K-S statistic (p=0.51). Symbolic subtraction exhibits skewness of -0.53 and kurtosis of -0.175, indicating slightly clustered to the left in normally distributed data and relatively flat which is supported by the K-S statistic (p=.01). Finally, examination of the skewness (-0.56) and kurtosis (-0.36) for pretest early mathematics motivation indicated moderately departure from normality, which is supported by the K-S statistic (p=0.200). Concerning post- testing, the distribution of dot addition is not normal (skewness= -1.16; kurtosis = 0.41; K-S statistic, p < 0.001). Symbolic addition appears to be moderately skewed to the right (skewness = -0.93) but somewhat nearer to normal peak (kurtosis = -0.02). The K-S statistic (p < 0.001) indicates the data are not normally distributed. Examination of the skewness (-0.81) and kurtosis (-0.22) for dot subtraction indicated significant departure from normality but with fairly normal peak, which is supported by the K-S statistic (p <.001). The skewness of symbolic subtraction was -0.63 which was unacceptable range where as the kurtosis (-0.26) was relatively a normal peak, but the data was not normally distributed (P= 0.017). Finally, posttest early mathematics motivation appears to be somewhat moderately skewed to the right (skewness = -0.66) but with a fairly normal peak (kurtosis =-0.19), the K-S statistic (p=0.01). The tests indicate that most of dependent variables the assumption of normality was violated, the MANCOVA is robust to violations of this assumption, particularly in the case where an equal number of observations per treatment group is compared. As a result, no adjustments were made to the dependent variable data related to departures from normality.

Equality of Variance-Covariance Matrices. The third assumption to be tested for the dependent variables is constant variance of the dependent variable at all levels of the independent variables as well as the equality of covariance among the dependent variables across groups. The data are described as homoscedastic if the variance of the dependent variable is constant at all levels of the independent variables. If there is not constant variance, the data are described as heteroscedastic. To test the data for constant variance among the different levels of the independent variables, a Levene's test for constant variance was performed for each dependent variable as show in Table 28.

For pretesting, the Levene's tests for DA (groups: F(2,67)=2.66, p=.08), SA (groups: F(2,67)=2.36, p=.10), DS (groups: F(2,67)=1.10, p=.34), SS (groups: F(2,67)=.80, p=.45) and early mathematics motivation (groups: F(2,67)=1.26, p=.29). Besides, for post testing, the Levene's tests for DA (groups: F(2,67)= 4.64, p=.013), SA (groups: F(2,67)=3.90, p=.02), DS (groups: F(2,67)=2.44, p=.09), SS (groups: F(2,67)=3.34, p=.04) and early mathematics motivation (groups: F(2,67)=2.39, p=.1). Except three, most of the results of the tests for constant variance for each dependent variables were not significant. So, this was an acceptable value of Levene's Test of Equality of Error Variances for the MANCOVA assumptions.

Table 28
Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Pretest DA	2.66	2	67	.08
Posttest DA	4.64	2	67	.01
Pretest SA	2.360	2	67	.10
Posttest SA	3.90	2	67	.02
Pretest DS	1.10	2	67	.34
Posttest DS	2.44	2	67	.09
Pretest SS	0.80	2	67	.45
Posttest SS	3.34	2	67	.04
Pretest EMM	1.26	2	67	.29
Posttest EMM	2.39	2	67	.1

Note: Computed using alpha = .05; DA=dot addition; SA=symbolic addition; DS=dot subtraction; and SS=symbolic subtraction, and EMM=early mathematics motivation

But, MANCOVA results indicated that the assumption of equality of covariance among the dependent variables across groups was violated, because Box's M Test of Equality of Covariance Matrices that tested equality of covariance matrices of the dependent variables across AIGG, AIGO, and control group was significant, F(55, 6251.94) = 2.64, *p* =0.00 (See Table 29).

Table 29
Box's Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.
192.238	2.64	55	6251.945	.000

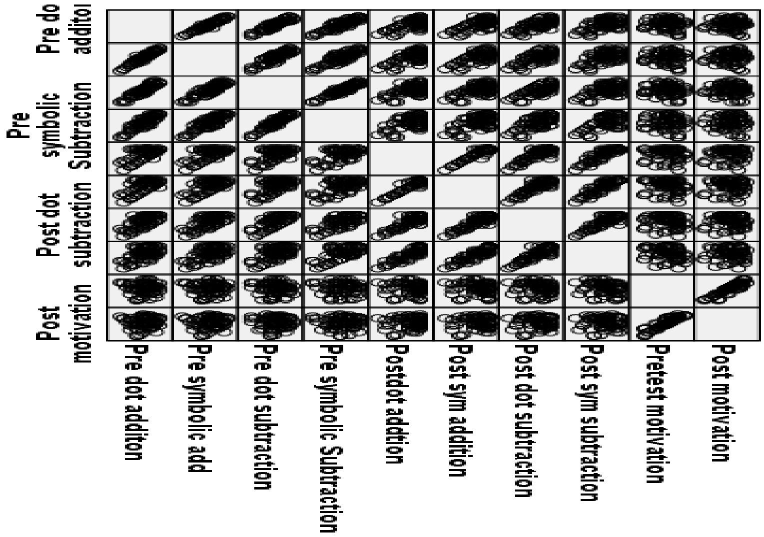
Note: Computed using alpha = .05

Elimination Outliers. Outliers are extreme data points that may not be representative of the data population and may result in spurious results if retained in the data set. While MANCOVA or ANCOVA is robust, it is appropriate to test the data for outliers and to examine any outliers for significant influence on the MANCOVA or ANCOVA results. To test for influential observations, each dependent variable was examined to determine if any of the observations qualified as an outlier by calculating mahalanobis distances using the regression menu (Tabachnick & Fidell, 2012). The mahalanobis distance of each student was found but to decide whether a case is an outlier, the Mahalanobis distance value was compared against the alpha value of 0.001 (this is obtained using a chi-square taking the ten variables (five pretests and five posttests) as a degree of freedom (df). Comparing the maximum value of the mahalanobis distance (in this study one student had 20.6 with a p-value of 0.008), no outliers were identified since the p-value is not lower than 0.001 level. This analysis didn't pick up on any cases that have a strange pattern of scores across the ten variables.

The Linearity. The linearity assumption means that there is a linear relationship between the set of the independent variables and the dependent variable. This assumption was assessed through plot the regression standardized residuals and the dependent variable (math scores) as shown in Figure 11. As can be seen in the figure, the relationships between the variables were linear. This means, it was seen a scatter plot of scores with a straight line (roughly), not a curve. The assumption was also met as the graph showed no curvilinear relationship.

Figure 11

A Scatter Plot for Linearity



Homogeneity Regression Slope. This assumption is important, only if, to carry out a step down analysis. This approach is used when there is some theoretical or conceptual reason for ordering dependent variables (Pallant, 2011).

Therefore, the assumption of normality and Box's Test of Equality of Covariance Matrices were violated, but Levene's Test of Equality of Error Variances was at acceptable value. In face of the assumption violation, small sample size and unequal N values, utilizing Pillai's Trace test is the appropriate one and which is the most robust of the multivariate tests (Tabachnick &Fidell, 2012).

Secondly, before conducting the experiment, the pretesting analysis was made; Table 30 shows two experimental groups and one control group descriptive and inferential statistics on addition, subtraction, and early mathematics motivation.

Table 30

Test of One Way MANOVA, Mean (SD) of Pretest Results

Groups	Addition		Subtraction		Motivation
	DA Mean(SD)	SA Mean(SD)	DS Mean(SD)	SS Mean(SD)	EMM Mean(SD)
With AIGG	8.80 (2.64)	7.75 (2.50)	7.75 (2.62)	6.87 (2.45)	39.46 (15.66)
With AIGO	8.12 (2.97)	7.17 (2.91)	7.21 (2.84)	6.12 (2.69)	33.00 (10.33)
Control	8.37 (3.08)	7.37 (3.08)	7.37 (2.57)	6.54 (2.55)	39.83 (16.05)
Sum of Squares	5.44	4.19	3.70	6.78	708.36
F	0.32	0.26	0.25	0.51	1.74
P	0.72	0.77	0.77	0.60	0.18

Note: Computed using alpha = .05; DA=dot addition; SA=symbolic addition; DS=dot subtraction; and SS=symbolic subtraction, and EMM=early mathematics motivation

The independent one way MANOVA test showed that the three groups scored similarly on the measures of arithmetic achievement and early mathematics motivation, namely (p =0 .72, DA; p = 0.77, SA; p = 0 .77, DS ; p = 0.60, SS; and p= 0.18, early mathematics motivation). Results showed no significant differences between the treatment and control groups on either of the pretest measures (all p >.05).

*4.4.2. Main Finding on the Effect of Concrete Fading Intervention on A*rithmetic *Achievement*

The results of the effect of concrete fading arithmetic instruction using Gabat'a for instruction and game purposes on arithmetic achievement of students with MD were conducted utilizing General Linear Modeling (GLM) of Multivariate Analysis of Covariance (MANCOVA) via controlling some of the major demographic variables. The 3x2 mixed MANCOVAs was organized to test for main effects of experimental conditions (AIGG, AIGO versus control group) as a between-participant factor on arithmetic achievement (symbolic-arithmetic versus dot-arithmetic) with sum-type (addition, subtraction) and time (pretest, posttest) as within-participant factors as well as to test for interaction effects.

The mean arithmetic test scores with SD can be found in Table 31. These descriptive statistics were placed for the pretest, posttest of addition (dot, symbolic) and subtraction (dot, symbolic), providing for the control, experimental one, and experimental two groups. It can be seen from the Table that the scores for all three groups improved from the pretest to the posttest, but that the scores for the AIGG experimental group improved more than the scores for the other two groups. Scores for the control group improved less than the scores for the other two groups. For detail analysis, further inferential statistics was carried out.

Table 31

Mean of Arithmetic Achievement Scores (SD) on the Arithmetic Test

	Number Notation	Arithmetic Operation	Groups	Pretest Mean(SD)	Posttest Mean(SD)
Arithmetic Achievement	Dots	Addition	With AIGG	8.78 (2.70)	14.30 (1.61)
			With AIGO	7.96 (2.91)	13.30 (2.20)
			Control	8.37 (3.08)	10.37 (3.08)
		Subtraction	With AIGG	7.70 (2.67)	13.74 (1.79)
			With AIGO	7.13 (2.88)	12.74 (2.40)
			Control	7.37 (2.57)	9.37 (2.57)
	Symbolic	Addition	With AIGG	7.74 (2.56)	13.91 (1.93)
			With AIGO	6.96 (2.79)	12.61 (2.48)
			Control	7.375 (3.08)	9.375 (3.08)
		Subtraction	With AIGG	6.83 (2.50)	13.35 (1.99)
			With AIGO	6.04 (2.72)	11.91 (2.54)
			Control	6.54 (2.55)	8.54 (3.11)

The results of a MANCOVA analysis indicate that there is a significant difference ($p<0.000$) between three groups in the post-test of addition (dot and symbolic) and subtraction (dot and symbolic) achievement. As depicted in Table 32, Pillai's Trace test of 0.24 was significant, $F(8, 130) = 2.2$, $p < .05$, and rejected the hypotheses that population means on the dependents were the same for control and treatment groups. The multivariate $\eta^2 = 0.12$ indicated 12 % of multivariate variance of the dependent variables was associated with the group factor. The partial η^2 value is the proportion of variance of the two dependent variables related to the group factor where 0.12 is considered medium effect size (Green &Salkind, 2014). The effect size result of 12% improvement and the observed power indicated that the sample size for the MANCOVA analysis was adequate. In summary, the results showed that AIGG and AIGO instruction enhance addition (dot and symbolic) and subtraction (dot and symbolic) achievement of students with MD.

As shown in Table 32, the within subject analysis was performed utilizing, the value for Pillai's trace for time (pretest and posttest) was 0.98, with a sig value of 0.000. Since p value is less than 0.05, it can be concluded that there is a significant effect for time. This indicated that there was a change in scores of arithmetic across the two different time periods (pretest and posttest). It was also needed to assess the effect size of this result. The value obtained of Partial Eta Squared (η^2) given in the Multivariate Tests output box for time in this study was 0.98. Using the commonly applied guidelines proposed by Cohen et al. (2000): 0.01=small effect, 0.06=moderate effect, 0.14=large effect, this result suggested a very large effect size. In addition, the Group x Time interaction effect was significant, Pillai’s Trace = 0.97, $F(8,130) = 15.42$, $p= 0.00$, partial $\eta^2= 0.49$ (see Table 32), demonstrating that the students’ arithmetic score increased from pretest to posttest on account of the intervention delivered in the form of concrete fading instructional approach using gabat’a as a game and teaching aid.

Table 32

The MANCOVA for Arithmetic Achievement as a Function of Group, Time and Interaction Between Condition and Time

Effect	Pillai's trace Value	F	Hypothesis df	Error Df	Sig.	Partial η2	Noncent. Parameter	Observed Power
Groups	0.24	2.2	8.00	130.00	0.03	0.12	17.52	0.84
Time	0.98	1084.40	4.00	64.00	0.00	0.98	4337.61	1.00
Group*Time	0.97	15.42	8.00	130.00	0.00	0.49	123.361	1.00

Note. Computed using alpha = 0.05

Both main effects and interaction effects were closely examined. If the interaction term is found to be significant like the main effect, pair-wise comparison analyses would be conducted to determine where the significant differences lie, the comparisons were done as part of MANCOVA output to compare the arithmetic achievement from AIGG to AIGO, AIGG to control and AIGO to control. As can be seen in the Table 33, the AIGG group displayed a typical significant superiority all domains on arithmetic achievement (Dot Addition, p=.002; Symbolic Addition p=.001; Dot Subtraction, p=0.001; and Symbolic Subtraction, at p=0.000) than control group group; and there was significant difference between AIGO and control group in all domains at p<0.05, except a marginal significant of dot addition achievement at p=0.067. However, there was no significant difference between AIGG and AIGO, and in all domains of arithmetic achievement at p>0.05, with the exception of a marginal significant difference of symbolic subtraction achievement at *p*=0.059.

Table 33

Pair-wise Comparisons

Measure	(I) Conditions	(J) Conditions	Mean (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
DA	AIGG	AIGO	0.911	.631	.154	-0.350	2.173
	AIGG	Control	2.072*	.624	.002	0.825	3.319
	AIGO	Control	1.160	.623	.067	-0.085	2.405
SA	AIGG	AIGO	.961	.663	.153	-.365	2.287
	AIGG	Control	2.356*	.656	.001	1.045	3.667
	AIGO	Control	1.395*	.655	.037	.086	2.704
DS	AIGG	AIGO	.758	.620	.226	-.481	1.997
	AIGG	Control	2.230*	.613	.001	1.005	3.455
	AIGO	Control	1.472*	.612	.019	.249	2.696
SS	AIGG	AIGO	1.114	.580	.059	-.045	2.274
	AIGG	Control	2.457*	.574	.000	1.311	3.604
	AIGO	Control	1.343*	.573	.022	.198	2.488

Note. *. The mean difference is significant at the .05 level: DA=dot addition; SA=symbolic addition; DS=dot subtraction; SS=symbolic subtraction; and EMM= Early math motivation

Additionally, using a pair-wise comparisons, there was a significant gain from the pretest to the posttest in all domains of arithmetic achievement, namely dot addition, symbolic addition, dot subtraction and symbolic subtraction, all at p=.00 (see Table 34).

Table 34

Pair-wise Comparisons Between Pre- and Post-test data of on Arithmetic Scores

Measure	(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference Lower Bound	95% Confidence Interval for Difference Upper Bound
DA	Pretest	Posttest	-4.290*	.135	.000	-4.559	-4.021
SA	Pretest	Posttest	-4.609*	.117	.000	-4.843	-4.375
DS	Pretest	Posttest	-3.867*	.119	.000	-4.105	-3.629
SS	Pretest	Posttest	-5.481*	.127	.000	-5.735	-5.226

Note: *. The mean difference is significant at the .05 level; DA=dot addition; SA=symbolic addition; DS=dot subtraction; and SS=symbolic subtraction.

Individual Differences in Arithmetic Achievement Scores. The third hypothesis proposed that there is no significant difference of the effects of concrete fading instruction using gabat'a as an instructional aids with or without its game on students' with MD achievement with differences in (a) gender, (b) difficulty type, and (c) PMK.

Gender differences in Arithmetic Achievement Scores. The Mixed MANCOVA indicated that, there is no significant difference on the main effect of gender on arithmetic achievement. As depicted in Table 35, the Pillai's Trace of .087 was not significant, $F(4,57)=1.36$, $p > .05$, and failed to reject the hypothesis that population means on the dependent variables were the same for male and female students with MD. However, two and three way interactions among Gender, Groups, and Time were not significant ($p > .05$ for all interactions) and the two way interaction between gender and groups was significant, the Pillai's Trace of 0.255, $F(8,116)=2.12$, $p < .05$ (see Table 35).

Table 35

The multivariate Effect of Gender and its Interaction with Condition and Time

Effect	Pillai's Trace Value	F	Hypothesis df	Error df	Sig.	Partial η^2	Noncent. Parameter	Observed Power
Gender	0.087	1.36	4.000	57.00	.260	0.087	5.427	0.396
Gender * Group	0.255	2.12	8.000	116.0	.039	.128	16.972	.826
Gender *Time	0.011	.16	4.000	57.00	.958	.011	.634	.081
Gender * Time*Group	0.156	1.23	8.000	116.0	.289	.078	9.820	.545

Note: Computed using alpha = 0.05

Arithmetic Achievement Scores as a Function of Difficulty Type. As shown in Table 36, to measure the difficulty type differences in the overall arithmetic achievement scores, the mixed MANCOVA for achievement revealed that there was no significant main effect of difficulty type on arithmetic achievement, Pillai's Trace = 0.11, $F(4,57) = 1.81$, $p > .05$, partial η^2=0.11. However, a significant interaction effect between condition and difficulty type, Pillai'sTrace = 0.39, $F(8, 116) = 3.49$, $p < .05$, partial $\eta^2 = 0.19$. Additionally, a two and three way interaction between Difficulty type * Time, and among Difficulty type * Time * Groups revealed that there was a significant interaction, having Pillai's Trace = 0.44, $F(4, 57) = 11.23$, $p < .05$, partial $\eta^2 = 0.44$, and Pillai's Trace = 0.42, $F(8, 116) = 3.9$, $p < .05$, partial $\eta^2 = 0.21$, respectively.

Table 36
Multivariate Effect of Difficulty Type

Effect	Pillai's Trace Value	F	Hypothesis df	Error df	Sig.	Partial η^2	Noncent. Parameter	Observed Power
DT	0.11	1.81	4.000	57.00	.139	0.11	7.255	.518
DT * Group	0.39	3.49	8.000	116.0	.001	0.19	27.905	.975
DT * Time	0.44	11.23	4.000	57.00	.000	0 .44	44.921	1.000
DT * Time * Group	0.42	3.90	8.000	116.0	.000	0.21	31.133	.987

Note: Computed using alpha = .05; DT= Difficulty types

Arithmetic Achievement Scores as a Function of Prior Mathematics Knowledge.

Conducting between and within subject MANCOVA design, differences of PMK of students with MD were analyzed in all domains of arithmetic achievement while controlling for gender, difficulty type, age, and language status. As can be clearly seen in the Table 37, the main effect of PMK and its interaction within groups and time was significant, all $p < 0.05$. That is, the main effect of PMK on arithmetic achievement, Pillai's Trace = 0.21, $F(4, 57) = 3.82$, $p <.05$, partial η^2=0.21. Additionally, the within interaction effect between PMK with time (pretest and posttest) revealed that there was a significant difference on arithmetic achievement of students having PMK from the time of pretest to posttest, Pillai's Trace = 0.15, $F(4, 57) = 2.52$, p=.05, partial η^2=0.15). Moreover, the interaction among PMK * Time * Groups revealed that there was a significant interaction among them, Pillai's Trace = 0.27, $F(8, 116) = 2.27$, $p < .05$, partial η^2 = .13). However, the interaction between PMK and groups was tested revealing a non significant difference between students with MD across the conditions in arithmetic achievement, Pillai's Trace = 0.16, $F(8, 116) = 1.30$, p =.03, partial η^2= 0.08.

Table 37
Multivariate Tests of Prior Mathematics Knowledge

Effect	Pillai's Trace Value	F	Hypothesis df	Error df	Sig.	Partial η^2	Noncent. Parameter	Observed Power
PMK	0.21	3.82	4.000	57.00	.008	.21	15.297	.868
PMK * Gp	0.16	1.30	8.000	116.00	.248	.08	10.439	.576
PMK * Time	0.15	2.52	4.000	57.000	.051	.15	10.088	.679
PMK * Time * Gp	0.27	2.27	8.000	116.00	.03	.13	18.126	.855

Note: Computed using alpha = .05; PMK= Prior Mathematics Knowledge; Gp=Group

4.4.3. Effect of Concrete Fading Arithmetic Intervention Utilizing Gabat'a on Early Mathematics Motivation

A follow-up univariate analysis for early mathematics motivation was conducted, see Table 38. The analysis indicated a significant group differences for early mathematics motivation scores [F= 3.18, p =.048, Partial η^2=0.09], time differences (pretest to posttest) for early mathematics motivation scores [F=13.20, p =.001, Partial η^2=0.18], and there was also a significant interaction between groups and time for early mathematics motivation, [F=65.62, p =.000, Partial η^2=0.68]. The interaction indicated that the scores for all the three groups improved from the pretest to the posttest.

Table 38

Univariate Tests, the Effect of Conditions, Time and Interaction on Early Mathematics Motivation

Effects	Sum of Squares	Df	Mean Square	F	Sig.	Partial η^2	Noncent. Parameter	Observed Power
Groups	2217.96	2	1108.981	3.18	.048	.093	6.358	.588
Time	78.55	1	78.549	13.20	.001	.176	13.200	.947
Group * Time	781.05	2	390.525	65.62	.000	.679	131.250	1.000

Note: Computed using alpha = .05

Individual differences in Early Mathematics Motivation Scores. Following the previous analysis, differences in gender, difficulty type and PMK for early mathematics motivation scores was examined using a mixed MANCOVA model with gender and other factors as a main effect. Gender, groups and other factors considered as an independent measure and interaction between time and gender and other factors as a repeated measure. Language status, age, and etc. were taken as covariates.

Gender Differences in Early Mathematics Motivation Scores. Based on the mixed MANCOVA analyses, the univariate analysis was conducted and it indicated that there was not main effect of gender on early mathematics motivation. That is, the individual participants with MD associated with early mathematics motivation scores were not significantly differed by gender. As can be depicted in Table 39, the two and three way interaction among gender, time and groups were not significant, for all interaction p>0.05. This indicated that there was no significant difference in the early mathematics motivation scores between male and females, where female's scores were not higher than males in terms of groups and time as well. However, the interaction between gender and group was significant at p=0.001 level.

Table 39

Univariate Analysis of the Effect of Gender, and Interaction of Gender, Conditions, Time on Early Mathematics Motivation

Effects	Sum of Squares	Df	Mean Square	F	Sig.	Partial η^2	Noncent. Parameter	Observed Powera
Gender	232.69	1	232.693	.655	0.42	.011	.655	.125
Groups* Gender	78.55	1	78.549	13.20	.001	.176	13.200	.947
Time* Gender	.001	1	.001	.000	0.99	.000	.000	.050
Group * Time* Gender	.080	2	.040	.007	0.99	.000	.013	.051

Note: Computed using alpha = .05

Early Mathematics Motivation as a Function of Difficulty Type. This section of the analysis assessed the difficulty type differences in the overall scores, applying the mixed MANCOVA. Specific to difficulty type, the univariate test was taken. The main effect of difficulty type was marginally significant, (F =3.54, p = .065) on early mathematics motivation scores, with a little tendency for students with MD showing slightly higher early mathematics motivation score than MDRD (see Table 40). However, this test result failed to show a significant interaction between difficulty type and time, difficulty type and groups, and difficulty type, time and groups, all >0.05.

Table 40

Univariate Analysis of Effect of Difficulty Type, Conditions, Time and Their Interaction on Early Mathematics Motivation

Effects	Sum of Squares	Df	Mean Square	F	Sig.	Partial η^2	Noncent. Parameter	Observed Power[a]
DT	1176.47	1	1176.47	3.54	.065	.056	3.545	.457
DT *Groups	1716.35	2	858.18	2.59	.084	.079	5.172	.497
DT *Time	14.85	1	14.85	2.60	.112	.042	2.601	.355
DT *Group*Time	26.29	2	13.14	2.32	.109	.071	4.603	.450

Note : Computed using alpha = .05; DT= Difficulty types

Early Mathematics Motivation as a Function of Prior Mathematics Knowledge. Pivoted on the univariate test of analysis from mixed MANCOVA, as can be seen Table 41, there was no significant main effect of PMK on early mathematics motivation score, (F =1.67, p = 0.20), indicating whether students with MD having PMK or not, did not show difference in early mathematics motivation scores. Additionally, PMK x Group interaction (F=0.62, p= .54), PMK x Time interaction [F=.02, p=.88] and PMK x Group x Time interaction (F=0.001, p= .99) were not significant.

Table 41
Univariate analysis on Effect of PMK, Conditions, Time and Interactions on Early Mathematics Motivation

Effects	Sum of Squares	Df	Mean Square	F	Sig.	Partial η^2	Noncent. Parameter	Observed Power
PMK	590.30	1	590.296	1.67	0.20	.027	1.672	.246
PMK*Groups	441.37	2	220.684	.62	0.54	.020	1.250	.150
PMK* Time	.137	1	.137	.02	.88	.000	.022	.052
PMK* Group *Time	.014	2	.007	.001	0.99	.000	.002	.050

Note: Computed using alpha = 0.05; PMK= Prior Mathematics Knowledge

In recapitulation, the major findings showed that arithmetic intervention using gabat'a has a significant effect on each component of arithmetic achievement and early mathematics motivation. However, the other findings are inconsistence such as variables interactions, gender differences, difficulty type, and PMK. Detail discussion of each outcome will be done on the next chapter.

4.5. Prediction on Early Grade Mathematics Achievement and Early Mathematics Motivation

This section entails a Pearson moment correlation, a report on results of bi-variate correlations among the constructs and results of sub-tests, linear and multiple regression analysis on the influence of students' early mathematics motivation on mathematics achievement and vice-versa, and canonical correlation analysis on the influence of predictors on dependent variables

4.5.1. Preliminary Analysis

Before running multiple regressions, various assumptions of parametric data analysis were checked against the research data just to be safe while interpreting findings. To begin from the first assumption, *ratio or interval scale,* variables in CNC, arithmetic and early mathematics motivation domains were ratio, ratio and interval scale respectively. *Sample size,* in this dissertation study, the number of participants in each independent variable was 72. This number is enough to run multiple regressions (Tabachnick & Fidell, 2013). Even for stepwise regression, there should be a ratio of 40 cases for every independent variable. More cases are needed if the dependent variable is skewed. *Independent observations* is achieved through a between-subjects design to test differences with respect to experimental groups, gender, and session time; and random assignment of participants to each of the treatment groups by applying stratified random sampling (see page 92). In addition, each participant worked individually and performed the experimental task at one time. As a result, each of the observations is independent of all other observations for the dependent variables. For the part of the multiple regression procedure, 'collinearity diagnostics' indicates whether there were problems with multi-collinearity or not. The results are presented by labeled coefficients in Table 42. All the variables except the dot addition and symbolic subtraction, the two values tolerance and VIF (Variance inflation factor) were more than 0.1 and less than 10, respectively. The multi-collinearity assumptions were not violated for all variables except the dot and symbolic addition.

Table 42

Collinearity Statistics

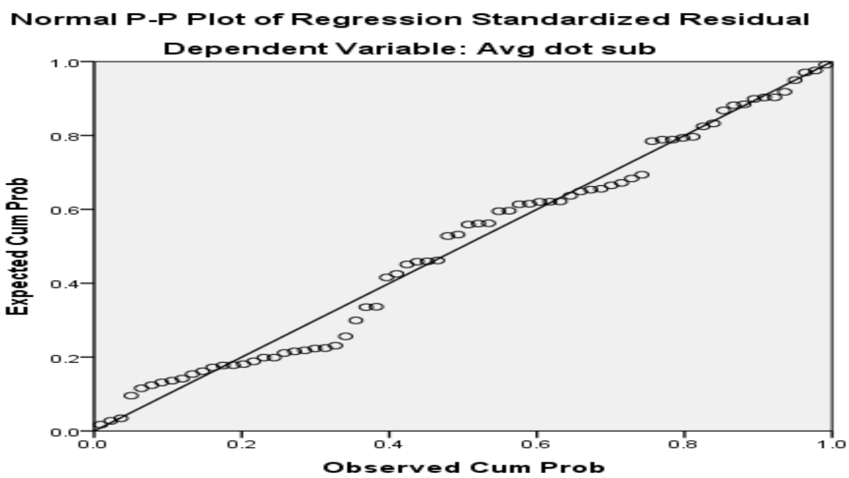
Model		Tolerance	VIF
1	(Constant)		
	Average dot addition	.040	25.129
	Average symbolic addition	.040	24.782
	Procedural counting	.358	2.794
	Conceptual Counting	.430	2.325
	Number Identification	.307	3.253

Note: Multi-collinearity assumptions are not violated for value of VIF between 0.1 and 10

Outliers, Normality, Linearity, Residuals Homoscedasticity, Independence of Residuals, by inspecting the Normal Probability Plot (P-P) of the Regression Standardized Residual and the Scatter-plot, the normality assumptions can be checked through. The Normal P-P Plot in Figure 12, the data points lie in a reasonably straight diagonal line from bottom left to top right. This would suggest no major deviations from normality.

Figure 12

Normal Probability Plot (P-P) of the Regression Standardised Residual

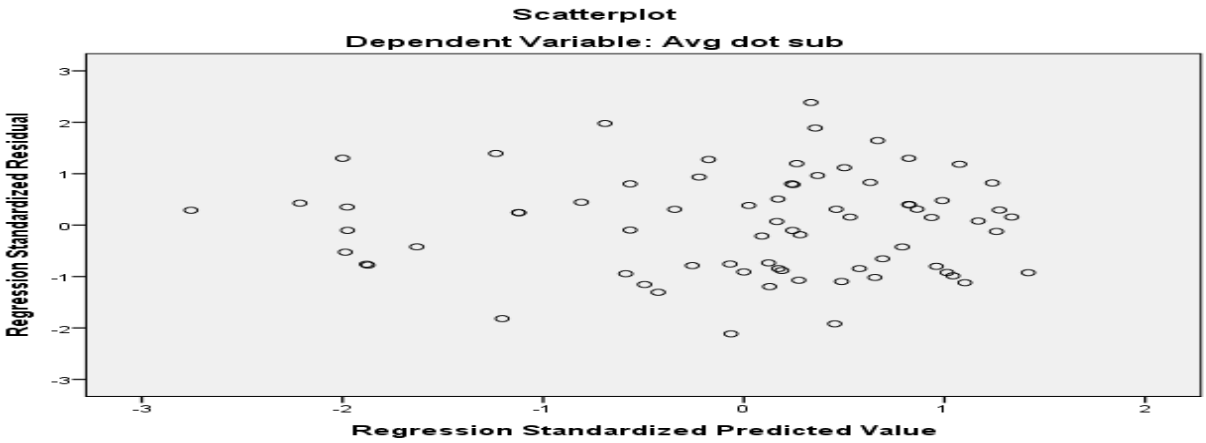


Note: Avg DS=Average dot subtraction

In the Scatter plot of the standardized residuals, the second plot displayed in Figure 13 shows most of the scores concentrated in the centre (along the 0 point). Deviations from a centralized point suggest some violation of the assumptions. So, there were no extreme deviations from the concentrated central area. Previously, by inspecting the Mahalanobis distances the presence of outliers can be detected. Alternatively, it is also possible to check using Scatterplot. Tabachnick and Fidell (2012) define outliers as cases that have a standardized residual (as displayed in the scatterplot) of more than 3.3 or less than –3.3. So, outlying residuals were not registered in this instance.

Figure 13

Scatter Plot of the Standardized Residuals



Therefore, almost all of the assumptions of parametric data analysis were not violated, by checking against the research data. It is safe to run multiple regressions while interpreting findings.

4.5.2. Main Finding of the Prediction on Early Numeral Achievement and Early Mathematics Motivation

Correlation matrix among the Early Grade Mathematics Sub-tests.

The study used CNC and arithmetic construct in assessing early grade numeral competency of students. The indictors included under each of these were the following:

i. Counting measure

- ✓ Procedural counting (PC): Oral Counting (OC), and Missing Number (MN).
- ✓ Conceptual counting (CC): One-To-One Correspondence (OTOC), Cardinality(C), and Stable order (SO).

ii. Number concept measure (NC): Number Identification (NI) and Quantity Discrimination (QD).

iii. Arithmetic measure: Dot Addition (DA); Symbolic Addition (SA); Dot Subtraction (DS); and Symbolic Subtraction (SS).

Identifying the extent of shared variances (or relationships) between paired sub-tests (indicators) was the focus of the Pearson r analysis. While the Pearson r was applied to find out the magnitudes of relationships, corresponding coefficients of determination were computed to analyze how much shared variance exists between paired variables. Table 43 displays the results of the paired correlation coefficients.

Table 43
Correlation Between Subtests

	Sub-test	1	2	3	4	5	6	7	8	9	10	11
1	OC	1	.18	.38**	.48**	.14	.58**	.35**	.53**	.53**	.51**	.44**
2	MN		1	.40**	.26*	.48**	.56**	.37**	.39**	.36**	.38**	.35**
3	C			1	.47**	.62**	.48**	.21	.62**	.62**	.61**	.59**
4	OTOC				1	.52**	.66**	.17	.70**	.69**	.61**	.55**
5	SO					1	.40**	.17	.55**	.54**	.55**	.52**
6	NI						1	.30*	.68**	.68**	.65**	.57**
7	QD							1	.36**	.37**	.43**	.43**
8	DA								1	.98**	.91**	.89**
9	SA									1	.90**	.89**
10	DS										1	.93**
11	SS											1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 43 shows that the zero-order or bivariate linear correlations within and between the subtests of the three constructs: CNC, and arithmetic, without controlling the effect of any other variable that might affect the relationships. Interestingly, all paired Pearson Correlation values (r) were found to be statistically significant, $r \gtrsim 0.30$, $p < 0.01$ or , $p < 0.05$, 2-tailed , except five pairs of correlation. For getting more clarity, the Pearson's r was categorized into groups of five: four within each of the PC, CC, NC and arithmetic constructs, and one between the constructs. In the correlation matrix, the area of correlation values within the PC sub-tests is shaded light pink, light orange for CC, that of NC sub-tests light green and arithmetic was shaded with light blue and the cross correlation is all light darker. Paired relationships within the construct subtests procedural counting (OC & MN), conceptual counting (OTOC, C & SO), number concept (NI & QD) and arithmetic (DA, SA, DS & SS) were found to be ($r \leq .3$, $p>.05$, 2-tailed) , ($.45 \leq r \leq .65$, $p<.01$, 2-tailed), ($r \simeq 0.30$, $p<.05$, 2-tailed) , ($.85 \leq r \leq 1$, $p<.01$, 2-tailed), respectively. However, the between constructs for pair cross correlation were ranged from very small r of 0.14 to 0.26, that was, between SO and OC(0.14), MN and OTOC(0.26), C and QD(0.21), OTOC and QD(0.17), SO and QD (0.17).

First, the r values within PC construct measures were extremely low in comparison to the values of other within construct measures and most of the indices in the cross-construct sub-tests' correlations. This tells that the values of r within PC constructs seem extremely weak to predict linear relationships in the context of early grade mathematics learning. That is, Cohen et al. (2000) suggested that group predictions based on correlations ranging from .35 to .65 are likely to be crude unless combined with other supporting evidence of correlations in multiple regression models. However, correlations within this category do not provide sufficient ground for individual prediction. Correlation values greater than 0.65, one the other hand, are helpful to make accurate predictions for most purposes. Hence, for procedural counting, the correlation values between OC and MN (r=0.18), for conceptual counting, OTOC and C (r=.47), OTOC and SO (r=.52) and C and SO (r=.62), and as per number concept, NI and QD (r=0.3) were found to be weak indices for prediction purposes. However, for arithmetic construct, the correlation among the four subtests are extremely acceptable, DA and SA (0.98), DA and DS (0.91), DA and SS (0.89), SA and DS(0.90), SA and SS(0.89), and DS and SS(0.93). The correlation values within the measures of CC, NC and arithmetic construct seemed higher than those within the PC construct. Based on the findings,

(i) C, OTOC and SO seem to have better contributions within the measures of CC construct for each demonstrated better relationship with the others in the construct; and

(ii) DA, SA, DS and SS have the highest shared variance, nearly 96%, for DA and SA ($r^2 = (.98)^2 = 0.96$) followed by that of DA and SS (0.89) and SA and SS(0.89)which amounted to 79% for each ($r^2 = (0.89)^2 = 0.79$).

When it comes to the cross relationship between sub-tests under the four constructs, overall the situation seemed relatively better than the paired correlations within the PC sub-tests but weaker than r values within the arithmetic construct sub-tests. The three highest paired cross linear correlations between the sub-tests of the four constructs were found between OTOC and DA (r=0.7), OTOC and SA (r=0.69), and NI plus SA (r=0.68).

Inter-correlation among subscales of early mathematics motivation. The first main question, in this section, concerned the relationship among intrinsic motivation (IM), identified regulation (IR) and controlled regulation (CR), when the three are measured under two constructs: CNC motivation and arithmetic motivation. All paired Pearson Correlation values (r) were found to be statistically significant, r >.30, p< .01, 2-tailed), see Table 44. The data analysis was done dividing in three shaded areas. In the correlation matrix, the area of correlation values within the CNC motivation sub-tests is shaded light purple, light yellow for within arithmetic motivation, and the cross correlation is all light pink. Paired relationships within the construct subtests CNC motivation (IM, IR, and CR), arithmetic motivation (IM, IR, and CR), between constructs for pair cross correlation were found to be (0.48 ≤r ≤0.75, p<.01, 2-tailed), (0.48 ≤r ≤0.76, p<0.01, 2-tailed), and (0.40 ≤r ≤0.95, p<0.01, 2-tailed). The three strong relationships were observed in cross correlation than within construct correlation. When assessed independently, IM in arithmetic and CNC, IR in arithmetic and CNC, and CR in arithmetic and CNC were extremely positively correlated (r = 0.89, p< .01), (r = 0.95, p< .01, and (r = 0.87, p< .01), respectively. The effect explains 79%, 90%, 76% of the variance respectively, suggesting that children's IM, IR and CR can be viewed as largely same ends of a two single dimension rather than orthogonal constructs. This doesn't mean that there wasn't strong correlation among the other within constructs. The correlation matrix for within constructs having a strong positive correlation between intrinsic motivation and identified regulation in the case of CNC (r= 0.75, p<.01), and between intrinsic motivation and identified regulation in the case of arithmetic (r= 0.76, p<.01).

Table 44

Inter-correlations among early mathematics motivation subscales

Measures	Sub-scale	1	2	3	4	5	6
CNC	IM	1	.75**	.48**	.89**	.68**	.40**
	IR		1	.65**	.70**	.95**	.62**
	CR			1	.39**	.55**	.87**
Arithmetic	IM				1	.76**	.48**
	IR					1	.65**
	CR						1

** Correlation is significant at the 0.01 level (2-tailed).

Regression Analysis among Counting, Addition, and Subtraction

i) Between Counting and Addition on Subtraction

By performing multiple regressions, the role of counting and addition as predictor of subtraction was evaluated. The enter method was applied in procedure of multiple regression analysis, because it was the most appropriate way to determine the association between all variables, and to check whether they are significant or not. It is separately predicted subtraction performance in two domains (dot and symbolic). First, hierarchical regressions were performed with domain of subtraction (dot and symbolic), as dependent variables. In each regression analysis, the focused CNC measure (procedural counting (PC), conceptual counting (CC) and number concept (NC)) was entered in the first step and addition (dot and symbolic) in the second.

In step 1, CNC with its level explains as a whole of 61% and 51.4 % of the variance of the subtraction variables of dot and symbolic that did also account for a statistically significant proportion of the variance R^2= 0.61, F change (3,68)=35.14, p = .000 . and R^2= 0.51, F change (3,68) = 23.99, p = .000, respectively (see Table 45). In step 2, addition (dot and symbolic) were added to the regression equation, the total variance explained by the model as a whole was 84%, F change (2,66) = 49.00, p < .00 for DS, and 80.40 %, F change(2,66) = 48.63, p < 0.00 for SS.

Table 45

Model Summary Hierarchical Regressions

						Change Statistics				
DV	Step	R	R2	Adjusted R2	Std. Error of the Estimate	R2 Change	F Change	df1	df2	Sig. F Change
DS	1	.78a	.61	.591	1.72989	.608	35.143	3	68	.000
	2	.92b	.84	.830	1.11387	.234	49.006	2	66	.000
SS	1	.72a	.51	.493	1.85645	.514	23.992	3	68	.000
	2	.90b	.80	.789	1.19811	.289	48.630	2	66	.000

Note. Computed using alpha =0 .05; DV=Dependent Variable; Avg=Average; DS=dot subtraction; and SS=symbolic subtraction.
a. Predictors: (Constant), NC, CC, and PC
b. Predictors: (Constant), NC, CC, PC, Avg SA, Avg DA
c. Dependent Variable: Avg DS

Specifically, the contribution of each of the variables under CNC and addition was further assessed. In Table 46, the coefficients table summarizes the results, with all the variables entered into the equation. Having a look at Sig**.** column, only one variable (DA) from the two control measures made a unique statistically significant contribution (less than .05) for DS and SS. According to their beta values, it is: DA (β = 0.62) for DS and DA (β =0.65) for SS. None of the variables PC, CC and NC made a unique contribution.

Table 46

Coefficients Regression Analysis of Counting and Addition on Subtraction

	Dot Subtraction					Symbolic Subtraction				
	USC		US			USC		US		
Model	B	SE	Beta	T	Sig.	B	SE	Beta	T	Sig.
1 (K)	1.43	1.60		.89	.376	1.87	1.720		1.088	.281
PC	.025	.049	.065	.52	.605	.010	.052	.027	.196	.845
CC	.085	.020	.417	4.31	.000	.082	.021	.414	3.851	.000
NC	.130	.041	.401	3.15	.002	.114	.044	.366	2.582	.012
(K)	.038	1.05		.036	.971	.397	1.125		.353	.725
PC	.003	.032	.006	.079	.937	-.013	.034	-.036	-.392	.697
CC	.002	.015	.010	.134	.893	-.007	.016	-.037	-.449	.655
NC	.036	.029	.113	1.28	.206	.013	.031	.043	.436	.664
DA	.626	.246	.624	2.55	.013	.628	.264	.649	2.375	.020
SA	.199	.239	.203	.834	.407	.256	.257	.271	.996	.323

Note. Computed using alpha =0 .05; USC=Unstandardized Coefficients; US= Standardized Coefficients; K=Constant, and SE=Std. Error.

ii) Between Counting and addition

The summaries of multiple regression results are presented in Table 47. In all cases, all variables are statistically significant ($p< 0.05$) and increase in R^2 when they are all introduced into the regression. The outcome from the multiple linear regression demonstrates that the group of CNC explain between 65.1 and 64.6 % of the variance of the DA and SA, respectively.

Table 47

A Model Summary Multiple Regression

					Change Statistics				
Measures	R	R^2	Adjusted R^2	SE of the Estimate	R^2 Change	F Change	df1	df2	Sig. F Change
DA	0.807[a]	.651	.635	1.62794	.651	42.262	3	68	0.000
SA	0.804[a]	.646	.630	1.67646	.646	41.364	3	68	0.000

Note. Computed using alpha =0 .05; Avg=Average

a. Predictors: (Constant), NC, CC, and PC;

b. Dependent Variable: Avg DA

Looking into each CNC variables in Table 48, it can be observed that the greatest weight of these variables in the prediction corresponds to PC (β = .616, P <0.02) for SA. Besides, CC (β = 0.48, P <0.000), and NC (β = .39, P<0.002) were for DA.

Table 48

Coefficients Regression Analysis between CNC and Addition

		Dot Addition					Symbolic Addition				
		USC		SC			USC		SC		
Model		B	SE	Beta	T	Sig.	B	SE	Beta	T	Sig.
1	(K)	1.38	1.55		.89	.38	-1.722	4.48			
	PC	.013	.047	.034	.28	.778	-.081	.107	.616	.034	.020
	CC	.101	.019	.482	5.2	.000	.062	.139	.732	.537	.379
	NC	.128	.040	0.39	3.2	.002	.049	.208	.701	.363	.232

Note. Computed using alpha =0.05; USC=U standardized Coefficients; SC=Standardized Coefficients; K= Constant; SE= Std. Error

Canonical Correlation of Early Mathematics Motivation and Achievement.

i) Between Achievement of CNC and Early Mathematics Motivation

Canonical correlation was enacted to examine the relationship between two variable sets having more than one variable, motivation traits (IM, IR and CR) as predictor (independent) and achievement variables of CNC (PC, CC and NC) as criterion (dependent). The canonical correlation coefficients and eigen value are presented in Table 49. Except the first one (λ= 0.635, F(9, 160.78)=3.66, P<0.05,), all the canonical correlation were not statistically significant. Therefore, only the first dimension is noteworthy in the context of this study. Dimension 1 showed that the two sets of variables possessed a canonical correlation of 0.583, and that early mathematics motivation positively influenced early numerical achievement (i.e., early mathematics motivation results in comparatively greater achievements).

Table 49

Canonical Correlations Elements of Early Mathematics Motivation and CNC Achievement

	Correlation	Eigen value	Wilks Statistic	F	Num D.F	Denom D.F.	Sig.
1	.583	.515	.635	3.66	9.000	160.78	.000
2	.184	.035	.963	.640	4.000	134.000	.635
3	.057	.003	.997	.224	1.000	68.000	.638

Note. Computed using alpha =0 .05

Table 50 lists the canonical correlation analysis results of this study; the first canonical variables in Set 1 (canonical loadings -0.399, -0.753, and -0.953) explain 54.5 % of the variance in set 1 by itself, IM, IR and CR (Table 51). The second Set 2 (canonical loadings: -0.056, -0.531, 0.323) explains 13% of the variance in set by itself, PC, CC and NC (Table

51). The independent variables of IM, IR, CR in Set 1 can explain 4.4 % of the variance in the dependent variables of PC, CC and NC in Set 2 and 18.5 % in the vice verse way.

Table 50

Canonical Loading, Standardized Coefficients, Redundancies and Corresponding Canonical Variates

Sets	First canonical variate	
Early mathematics motivation (Set 1)	Loading	Coefficient
Intrinsic motivation	-.399	.373
Identified regulation	-.753	-.511
Controlled regulation	-.953	-.801
CNC achievement (Set 2)		
Procedural counting	-.056	-.504
Conceptual counting	-.531	-1.025
Number concept	.323	1.325

Table 51

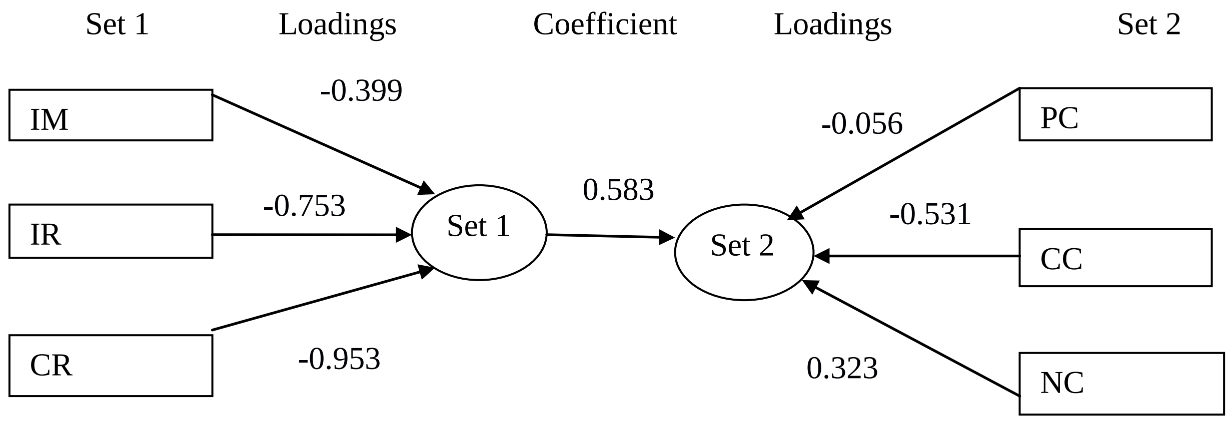
Proportion of Variance Explained

Canonical Variable	Set x by Self	Set x by Set y	Set y by Self	Set y by Set x
1	.545	.185	.130	.044
2	.330	.011	.163	.006
3	.125	.000	.708	.002

A path diagram of the canonical correlation is shown in Figure 14, in which motivation (IM, IR, and CR) positively influenced achievement of CNC (PC, CC, and NC) with r=0.583, r>0.3.

Figure 14

Path Diagram of the Canonical Correlation



ii) Between Motivation and Arithmetic Achievement

A canonical correlation analysis was also performed between the early mathematics motivation subscales and the arithmetic achievement tests. An alpha level of 0.05 was utilized. Cutoff correlations of 0.30 were used for interpretation of the canonical variates (Tabachnick & Fidell, 2012). A statistically significant relationship was not found between early mathematics motivation subscales (IM, IR, and CR) and the arithmetic subscales (DA, SA, DS, and SS), see Table 51. Then, all canonical roots were not significant, p >0.05. Therefore, canonical variates could not be interpreted.

Table 52

Canonical Correlations Elements of Early Mathematics Motivation and Arithmetic Achievement

	Correlation	Eigenvalue	Wilks Statistic	F	Num D.F	Denom D.F.	Sig.
1	.329	.121	.788	1.355	12.000	172.265	.192
2	.314	.109	.883	1.409	6.000	132.000	.216
3	.142	.021	.980	.	.	.	.

In recapitulation, with respect to correlational results, within the addition and subtraction constructs, the correction was highest, similar results were found in cross correlation as well. In addition, the multiple regression findings indicated that addition had a unique significant contribution for subtraction than counting.

Chapter Five

Discussion and Conclusion

5.1. Discussion

This discussion section incorporates the whole picture of the dissertation research starting from the brief general finding and its intervention approaches, the inquiry-based reflection of the researcher, the rendering of detail explanation and showing the direction and decision hinged on final outcomes. The main target is to make a synthesis of the essence conveyed to bring the search to its end but is not to repeat things as they appear in the preceding chapters. Hence, explicating in detail, this chapter brings brief delivering of the general findings and key concrete fading interventional approaches, and proceeds to the presentation of answers to the hypotheses formulated. It also presents implications to knowledge, research and further interventions and study, and limitation of the study. This section discusses predominantly the research findings presented in the result section. It is divided into three major parts

i. The effect of concrete fading instruction utilizing gabat'a on CNC and early mathematics motivation.
ii. The effect of concrete fading intervention using gabat'a on arithmetic and early mathematics motivation.
iii. Prediction on early grade mathematics achievement and early mathematics motivation.

The first section discusses results encompasses four primary research questions on participants' CNC achievement and early mathematics motivation together to run them utilizing one Multivariate Analysis of Covariance (MANCOVA) to test four hypotheses. This section is then tried to discuss CNC achievement and early mathematics motivation. As a supplementary, it touches the effects of individual differences (i.e., gender, PMK, and difficulty type) on CNC and early mathematics motivation. The second section focuses on arithmetic achievement and early mathematics motivation, having a similar pattern of discussion with section one but adds game as an intervention. The third section discusses the prediction of early numeral achievement and early mathematics motivation having five research questions. Based on the research questions, this section confers correlation of each subtest of CNC, arithmetic, and early mathematics motivation; the prediction of counting on arithmetic (addition and subtraction); the facilitation of addition on subtraction, the prediction of students' early numeral achievement from early mathematics motivation towards CNC, addition and subtraction. The last section comprises the implication, limitation of the study and future direction and ends up with conclusions.

5.1.1. The Effect of Concrete Fading Instruction Using Gabat'a on CNC and Early Mathematics Motivation

One of the purpose of the present study was to explore the effect of concrete fading early numerical intervention using Ethiopian gabat'a on enhancing CNC achievement and motivation of students with MD. On the whole, the findings suggest to support the hypothesis that the potential for using the concrete fading strategy using gabat'a to address the early numerical knowledge gap of the students with MD and enhance their CNC and early mathematics motivation. It is interesting that students in the CIGO group not only outperformed the control group on the CNC test, but they also showed significant performance on the EMMS. Besides, the main effect of time is significant, indicating that there was a change in scores of all CNC components and early mathematics motivation across the two different time periods (pretest and posttest). The two-way interaction effect between group and time was significant as well.

These findings are in line with other studies which have reported that the explicit instruction using the CRA sequence is effective, in teaching mathematics interventions for students who struggle in mathematics (Miller et al., 2011; Hilton & Flores, 2019) , and in motivation (Ibrahim, 2017). Another single subject experimental work, in support of the present study, on exploring the use of explicit instruction in teaching young children counting skills using received instruction for resultative counting and shortened counting, students showed improvement in counting skills (Hinton et al., 2015). Researchers also showed explicit instruction is very versatile and, therefore, has potential in counting instruction (Flores, 2010; Kaffar & Miller, 2011; Strozier, 2012). Making gabat'a board game as a supportive instructional aid is also vital. Alex de Voogt et al. (2018) indicated that a board game, similar to gabat'a, has been part of the curriculum and used as both for playing the game and teaching elementary mathematics concepts such as, counting, addition, and subtraction. Ramani and Siegler (2008) studied the effectiveness of linear number board games for improving the numerical knowledge. They added that children who played the number board game showed increased proficiency in numerical magnitude comparison, number line estimation, counting, and numerical identification. Using CRA method with gabat'a for CNC instructional purpose and getting exposure to touch beads as objects and then represent them with counting dots, and that increases students' ability to identify and compare number symbols, finally it makes them also to be more motivated. The current study was based on the Bruner theoretical instructional strategy plays an important role for those students in engaging in mathematics by extracting key mathematical concepts and eventually in developing abstract concepts by generating multiple representations, comparing those representations and analyzing them (Kim, 2020). In line with this, specifically, gabat'a in CRA instructional strategy is paramount important to teach conceptual counting such as cardinality, one to one correspondence and stable order utilizing physical gabat'a as a concrete stage and mental gabat'a as representational stage. Eventually, symbolic number identification and quantity discrimination are done in the abstraction stage of CNC. Therefore, CRA method using gabat'a can provide kinesthetic, auditory, visuo-spatial, and temporal cues on CNC. However, the present study differs from previous CRA research in that it addressed a variety of elements. For example, enacting a single gabat'a for each student as an instruction aids that facilitates the CRA sequence; and making CNC and early mathematics motivation are dependent variables.

On the other continuum, differences in gender, difficulty type, and PMK in terms of CNC achievement scores and early mathematics motivation are discussed. To begin, the main effect of gender, interactions among groups, gender, and time were not significant for CNC achievement scores and early mathematics motivation. This implies the means of CNC achievement and early mathematics motivation scores were the same for male and female students with MD, even with respect to time and group. The findings on gender difference of children with MD on the CNC achievement and early mathematics motivation are not invariant with other studies. The gender effect result of the present study contrasts with the report of the previous work (Jordan et al., 2006), where at the end of kindergarten, favors males for overall number sense, counting skills, number knowledge, nonverbal calculation, estimation, and patterns. Specifically, regarding the overall number sense and non-verbal calculation, it was exhibited a greater percentage of boys in high performing classes. Besides, boys are motivated more than girls on number tasks, even at an early age (Aunola et al., 2004; Eccles et al., 1990). However, in favoring the present study, Aunola et al. (2004) did not find gender differences in level of performance of math problems.

Considering the findings on difficulty type, it is indicated that there were no difficulty type main effect and interaction on the CNC task and early mathematics motivation. This tells that the means scores of CNC achievement and early mathematics motivation were the same for students with MD and with MDRD, across time and group as well. This study is in line with other previous studies, Geary et al. (2000) suggest in an easy counting activities

MDRD and MD only students demonstrated similar performance. Both students in the difficulty types exhibited understanding of basic counting principles. Besides, the experimental study on the timed retrieval of number facts, MDRD and MD-only students performed comparably, yet significantly below control students. In contrast, MD-only students may struggle with math because of weak number sense (Robinson et al., 2002). MD-only and MDRD differences are in fact due to number sense skills. Some research conducted finds MD-only and MDRD students perform comparably on fact retrieval tasks, even when time is not constrained (Micallef & Prior, 2004). Moreover, MD-only students perform better on untimed fact retrieval tasks than MDRD students (Andersson & Lyxell, 2007; Hanich et al., 2001; Jordan & Montani, 1997), but both groups of students perform similarly on timed fact retrieval tasks. Ultimately, in the present study, the performance of both groups of students were similar. This may be on account of easiness of concreting fading instructional strategy using gabat'a and learning simple counting and number concept.

Furthermore, the present study showed that students with MD having PMK scored the same with those who have not, in CNC and early mathematics motivation scores. This pattern of the present finding was also seen across groups and time. The skills and knowledge gap on CNC between them is closer on account of CRA instruction with gabat'a strategy. Besides, the students might encounter poor instructional environment in their KG classrooms. Then students might be, wrongly, discerned as MD. These justifications echo previous work of National Mathematics Advisory Panel (2008) and as it is clearly mentioned, the conceptual knowledge difficulties, such as procedural knowledge deficits, are likely to be at least partially a function of poorly designed curricula and instruction, and inadequate intervention support. Rajkumar and Hema (2017), also found that if previous KG teachers did not, explain concepts well, use effective teaching methods, or allow time for mastery and success, students' mathematics learning will be affected. Hence, CRA instruction in tandem with gabat'a narrows the gap between those groups.

5.1.2. The effect of Concrete Fading Arithmetic Intervention Using Gabat'a on Arithmetic Achievement and Early Mathematics Motivation

The next overarching purpose of this study was to investigate the efficacy concrete fading arithmetic intervention, on arithmetic achievement and early mathematics motivation of students with MD, using either gabat'a as an instructional aid or a game or both. Much like earlier and recent work on the effect of CRA (Kim, 2020; Hinton & Flores, 2019) and explicit (Baker et al., 2002; Gersten et al., 2005) instructional strategies on mathematics performance and early mathematics motivation (Ahmed et al., 2012; Ibrahim, 2017), the present study indicated that delivering these strategies using gabat'a as a teaching aid and game is significant for students with MD to show up progress in arithmetic achievement and early mathematics motivation. Looking at the results, a clear significant main effect of the three groups, session time (pretest and post test) and the interaction between groups and time were found on arithmetic achievement and early mathematics motivation. This is consistence with the related study of Ibrahim (2017) that showed a significant difference of the CRA approach on pupils' proficiency in fractions and motivation in learning fractions. Using CRA method with gabat'a for arithmetic instruction purpose and getting exposure to touch beads as objects and then represent them with a mental gabat'a, and that increases students' automaticity and accuracy to do the abstract arithmetic, finally it makes them to be more motivated.

In pair-wise comparison, the AIGG and AIGO groups reported greater gain in comparison with control group. However, no significant difference was exhibited between AIGG and AIGO in all subtests of arithmetic achievement, but not for early mathematics motivation. This apparently tells students with MD in AIGG group do not get advantages of making use of gabat'a as a game in comparison with students in AIGO but the reverse is true for motivation. This means that the gabat'a board game that students with MD played after the mathematics session did not show any cognitive effect in the increment of their arithmetic scores, but made them to be motivated. This pattern of finding, regarding arithmetic achievement, is incompatible with the works of Alex de Voogt et al. (2018). They expounded that a similar board game, gabat'a in Ethiopia and mancala in other countries, has been part of the curriculum and used as both for playing the game and teaching elementary mathematics concepts. Adapting the board game (mancala), it plays a role for teaching early mathematical concepts, counting, addition, and subtraction.

In addition, an experimental study of typical developing students shows the effectiveness of engaging students through board games on their academic performance was studied by Viray (2016) and several studies have also asserted that game-based instruction promotes learning interest and motivation (Burguillo, 2010; Dickey, 2011; Ke, 2008 ; Ebner & Holzinger, 2007). Moreover, enacting mathematical instruction via game and activities enhances interest, provides motivation, offers the opportunity of active participation and permanent learning by providing use of all sense organs in learning process (Turgut & Dogan Temur, 2017).

In the contrary with the aforementioned arguments and in support of the present study results of arithmetic achievement, playing game may not enjoyable for students since the game might be so challenges exceeding players' skills (Breuer & Bente, 2010). Similarly, the rules and procedure of gabat'a game might be difficult for first grader with MD and the gabat'a game has no any number symbol embedded in it to facilitate their skills in arithmetic. Applying CRA using *gabat'a* as an instructional aid is enormously advantageous rather than implicitly using *gabat'a* as a motivation game to enhance students' mathematics performance. Explicit instruction using the CRA sequence is effective in teaching mathematics interventions for students who struggle in mathematics because it first addresses conceptual knowledge, providing students with the experiences needed to make meaning of numbers and operations using objects, pictures, and drawings at the concrete and representational concrete levels (Miller et al., 2011). Hinged on this way, the intervention strategies of this study is entirely based on CRA which encompasses physical gabat'a as a concrete object such as counting beads and associating with plastic symbolic numbers, mental gabat'a as a representational level (dots), most efficient min counting strategy, and verbal counting strategy as abstract level. CRA method using gabat'a can provide kinesthetic, auditory, visuo-spatial, and temporal cues on arithmetic.

The further findings on disparities in gender, difficulty types and PMK in terms of arithmetic achievement scores and early mathematics motivation are discussed. The findings from the main effect of gender, interactions among Groups, Gender, and Time were not significant for arithmetic achievement. That implies the means of arithmetic achievement were the same for male and female students with MD, even with respect to time and group. Despite the main effect of gender was not significant, the interaction between gender and group was significant for motivation, specifying male or female students' with MD motivation is higher for those following CRA instruction using *gabat'a* as an instructional aids and a game. The result on arithmetic achievement is inconsistent, old studies with respect to typical developing students have shown that an advantage for boys in overall mathematics attainment (Benbow& Stanley, 1980). It is added that there is a stereotype that women score less than men when they take math exam (Ashcraft, 2002). But, in support of the present study result, Devine et al. (2012) revealed no gender differences emerged for mathematics performance. As per Kinzie and Joseph (2008), problem-solving modes showed no preference differences between genders.

With respect to early mathematics motivation, other previous researches show that the effects of gender on motivational components were observed. Girls are more intrinsically motivated towards reading and writing and are more regulated by identification towards writing than boys. In contrast, boys are more intrinsically motivated towards mathematics than girls (Guay et al. , 2010). But in sum, this study results parallel with this study and those of other studies (Eccles et al., 1993), and indicate that gender stereotypes may affect motivation processes in the early grades. Taking the overall motivation in this study, that is taking the intrinsic motivation and external motivation together turns out to be not having gender differences in motivation.

The findings on difficulty type specified that there were no differences between difficulty type on the arithmetic task; but there was marginally significant on early mathematics motivation scores, with a little tendency for students with MD showing slightly higher early mathematics motivation score than MDRD. Either MD or MDRD, students with MD showed improvement on arithmetic achievement from pretest to posttest across conditions. However, for motivation, this test result failed to show a significant interaction between and among difficulty type, groups and time, indicating no difference in motivation between MD and MDRD.

The present study is compatible with other experimental studies regarding arithmetic in terms of difficulty type, Micallef and Prior (2004) did not detect difficulty type differences on basic facts in mathematics. Andersson and Lyxell (2007), and Hanich et al. (2001) also mentioned there were no differences between difficulty type on the untimed task. MD-only and MDRD students performed significantly worse and took longer to solve problems than chronological age controls. In addition, other research has not demonstrated differences between students with MD + reading difficulties (RD) and MD-only on number combinations (Geary et al., 1999). Differently, a related literature on second graders focuses on untimed arithmetic calculations, MDRD students performed significantly worse than MD-only students (Powell et al., 2011). Moreover, at third grade, Jordan and Montani (1997) specified that MD-only students performed significantly better than MDRD students under timed conditions across simple and complex calculations. Andersson and Lyxell (2007) studied second, third, and fourth graders on timed and untimed arithmetic tasks. On arithmetic, in comparison with average-performing peers, students with MD-only responded correctly as many number combinations as average-performing peers, but only when given more than 3 seconds to answer. MDRD students did not solve as many problems correctly regardless of the time provided.

The present study showed that students with MD having PMK scored better in arithmetic than those who have not. This trend was seen across groups. But, this is not registered in motivation. Apparently, the KG program is designed to prepare children for the formal education to read, write, and calculate numbers. In contrary, Ching and Wu (2019) demonstrate on their concrete fading study that for inducing mathematical knowledge for children with lower PMK, concrete representations were more efficacious than abstract representations. Consistent with this proposition on arithmetic scores, a sizable number of studies have demonstrated PMK have impact on the current mathematics achievement (Rajkumar & Hema, 2017; Asfaw, 2015). As per Rajkumar and Hema (2017), student's PMK and previous experiences with mathematics are the best predictors of future success and also previous instructional experiences also can have a significant impact on achievement. If previous KG teachers did not explain concepts well, use effective teaching methods, or allow time for mastery and success, students' mathematics learning will be affected.

For students' with MD motivation, in CRA methods using *gabat'a* as a game and an instructional purpose was a new experience for them. So the intervention might not bring any difference as a function of PMK. The other views, perhaps, the previous bad teaching techniques and curriculum, students weren't able to develop the deep concept understanding and their math achievement will suffer. With respect to game playing, the findings of Rajkumar and Hema (2017) indicated that PMK did not play a significant role in achievement and motivation of the participants who played the games.

*5.1.3. Prediction on Early Grade Mathematics Performance and Mathematics Motivati*on

The major focus of this part is to discuss the relationship within and cross achievement of counting, addition and subtraction, and early mathematics motivation. The findings have led to key major discussion points. To begin, the results of the correlational analyses within each subtest of CNC, arithmetic, and early mathematics motivation indicate that the paired relationships within the construct subtests, such as procedural counting (oral counting (OC) & missing number (MN)), conceptual counting (one to-one correspondence (OTOC), cardinality(C), and stable order (SO), number concept (number identification (NI) and quantity discrimination(QD)) and arithmetic (dot addition, symbolic addition, dot subtraction and symbolic subtraction) were found to be significant expect between OC and MN. Specifically, the correlation within the four subtests of arithmetic construct, dot addition , symbolic addition, dot subtraction, and symbolic subtraction, is extremely acceptable, all each other, $r > 0.89$, *and* have the highest shared variance. Besides, one to-one correspondence (OTOC), cardinality(C), and stable order (SO) seem to have better contributions within the measures of counting concept construct for each demonstrated better relationship with the others in the construct. All significant results are compatible with the literature of The Early Grade Mathematics Assessment (EGMA) instrument of Reubens (2009), BANUCA screening tool (Räsänen & Natayi, 2011), and The Dyscalculia Assessment (Emerson & Babtie, 2014), and Koponen et al.(2007). Similary, both conceptual and procedural counting are highly correlated with other part of mathematics (LeFevre, 2006). However, in contrast with EGMA of Reubens (2009), the non-significant result showing that the correlation values within procedural counting construct measures were extremely low in comparison to the values of other within construct measures and most of the indices in the cross-construct sub-tests' correlations. Reubens (2009) relocated the missing number task into the counting task after feedback from the EMEP. However, this study suggests returning the missing number (MN) in the former category since students with MD in the present study exhibited better performance on OC and they found MN as a bit difficult. Thus, this seems procedural counting is extremely weak to predict linear relationships in the context of early grade mathematics learning. The present study supports the definition of Koponen et al. (2007), procedural counting is the ability to correctly sequence numbers orally without reference to external visual stimuli.

Secondly, to evaluate the role of counting and addition as predictor of subtraction, a hierarchical regression was performed. In step 1, CNC with its levels procedural counting, conceptual counting and number concept were entered and explain as a whole of 61% and 51.5 % of the variance of the subtraction variables of dot and symbolic that did account for a significant proportion of the variance. In step 2, addition (dot and symbolic) were added to the regression equation, the total variance explained by the model as a whole was 84% for dot subtraction, and 80.4 % for symbolic subtraction. This conspicuously shows that both CNC and addition are predictors of subtraction.When students begin addition and subtraction, students often solve addition problems more successfully than subtraction problems (Shinskey et al., 2009). This is related to the fact that students learn counting forward well before they succeed in counting backward. The addition skills of students, even students who are struggling with mathematics, are generally stronger than their subtraction skills. This is apparent in that many students solve subtraction problems more efficiently when they use addition skills (Torbeyns et al., 2009). While students may understand the principle of subtraction, they often lag in their ability to understand that subtraction is the inverse of addition (Baroody et al., 2009). Students who understand the relationship between addition and subtraction (i.e., addition is the inverse of subtraction and vice versa) demonstrate better conceptual knowledge and better subtraction performance than students who do not understand this relationship (Gilmore & Papadatou-Pastou, 2009). In addition, as children develop understanding of the relationship between subtraction and addition (Baroody, 1999), knowledge of addition number concepts facilitates knowledge of subtraction number concepts.

Specifically, the contribution of each of the variables under CNC and addition was further assessed. Only one variable (dot addition) from the two control measures made a unique significant contribution for subtraction (dot and symbolic). In order of importance (according to their beta values), it is dot addition ($\beta = 0.62$) for dot subtraction and dot addition ($\beta = 0.65$) for symbolic subtraction. None of the variables procedural counting, conceptual counting, and number concept made a unique contribution.

Additionally, between the relation of CNC and addition, when it comes to the cross relationship between sub-tests under the four constructs, the three highest paired cross-linear correlations between the sub-tests of the four constructs were found between one to one correspondence and dot addition, one to one correspondence and , symbolic addition, and number concept and , symbolic addition, $r > 0.65$. In relation to this, further multiple linear regression analysis between counting and addition was done; it shows all cases are significant ($p < 0.05$). This finding is compatible with the work of Desoete et al. (2009) in that counting skills are seen as one strong predictor for arithmetic skills. Similarly, the study of Jordan et al. (2009), where in kindergarten number sense instruction predicted later pertinent mathematics skills in calculation fluency, working memory, and spatial reasoning, with number combinations and number knowledge. Besides, it is stressed that counting per se is particularly important for later mathematics (Carrasumada et al. 2006), in part due to its explicit role in the transition to formal arithmetic in which counting is used in early calculation (Geary, 2004). Counting also allows for the automatic use of math-related information which would permit other cognitive resources to be devoted to more complex tasks, such as problem solving (Gersten & Chard, 1999). Precisely, further, the outcome demonstrates that the group of CNC explain between 65.1 and 64.6 % of the variance of addition domains (dot and symbolic). More specifically, for each CNC variables, it can be observed that the greatest weight of these variables in the prediction corresponds to procedural counting ($\beta = 0.62$, $P < 0.02$) for symbolic addition. Besides, conceptual counting ($\beta = 0.48$, $P < 0.000$), and number concept ($\beta = 0.39$, $P < 0.002$) were for dot addition. It is not specific, but the findings are supported by Stock et al. (2009) , indicating the important counting principles in kindergarten, including stable order, one-to-one correspondence, and cardinality predicted later grade math facts and arithmetic, whereas Praet et al. (2013) added that both procedural counting and conceptual counting predict a composite grade 1-math outcome.

The two constructs (conceptual counting and number sense) seem both self-standing and interdependent. The counting concept component promotes the understanding of counting abilities, system of counting and quantity identification. The Number Sense deals with the skills involved in counting, connecting symbols and number names, comparing quantities, and the technicalities of operations. Understanding how to count does not necessarily equip the individual with the ability of counting as the later requires task-based practice. On the other hand, proficiency in computational skills should be supported by adequate and relevant conceptual understanding of the background knowledge. It is the appropriate integration between knowledge acquisition and computational skills that produce number, operational and problem solving competencies (National Council of Teachers of Mathematics, 2000). Therefore, though which one of the two constructs precedes the other or to what extent one influences the other is not yet clear (Smith, 2010), both should be recognized as fundamental bases for proper start in learning mathematics.

With respect to the inter-correlation among subscales of early mathematics motivation, the relationship among intrinsic motivation, identified regulation and controlled regulation are measured under two constructs, CNC motivation and arithmetic motivation. Paired relationships within the construct subtests CNC motivation (intrinsic motivation, identified regulation and controlled regulation), arithmetic motivation (intrinsic motivation, identified regulation and controlled regulation), between constructs for pair cross correlation were found to be significant, all are $0.39 \leq r \leq 0.95$, $p<0.01$, 2-tailed). Strong relationships were observed in cross correlation than within construct correlation. In the contrary to this study, according to SDT, motivation types can be ordered along a self-determination continuum. Motivation types are therefore expected to relate to each other in a simplex like pattern, with stronger positive correlations between adjacent than distant motivations (Guay et al., 2010). For example, identified regulation and intrinsic motivation should be positively and moderately correlated, and this correlation should be higher than the correlation between intrinsic motivation and controlled regulation. Plausibly, the present study indicated the cross correlation is stronger than within construct correlation, since motivation types (intrinsic motivation, identified regulation and controlled regulation) is the same in CNC and arithmetic.

Thirdly, canonical correlation was enacted to examine the relationship between two variable sets having more than one variable, motivation traits (intrinsic motivation, identified regulation and controlled regulation) as predictor (independent) and achievement variables of CNC (procedural counting, conceptual counting and number concept) as criterion (dependent). Except the first canonical variate, all the canonical correlation were not significant. Therefore, only the first dimension is noteworthy in the context of this study. This shows that the two sets of variables possessed a canonical correlation of 0.583, indicating that mathematics motivation (intrinsic motivation, identified regulation and controlled regulation) positively influenced achievement of CNC (procedural counting, conceptual counting and number concept). There is high support for the positive influence of early mathematics motivation on mathematics achievement (Marcelino et al., 2017). However, motivation does not predict achievement at any time (Garon-Carrier et al., 2016).

Specifically, until recently it is unclear whether it is the type of motivation that drives achievement, the level of achievement that drives the type of motivation or some combination of the two. But, the canonical correlation analysis results of this study shows the first canonical variables in Set 1 (canonical loadings -.399, -.753, and -.953) explain 54.5 % of the variance in set 1 by itself, intrinsic motivation, identified regulation and controlled regulation. The second Set 2 (canonical loadings: -.056, -.531, .323) explains 13% of the variance in set by itself, procedural counting, conceptual counting and number concept, respectively. The independent variables of intrinsic motivation, identified regulation and controlled regulation in Set 1 can explain 4.4 % of the variance in the dependent variables of procedural counting, conceptual counting and number concept in Set 2 and 18.5 % in the vice verse way. A bit specifically, the three elements of motivation (intrinsic motivation, identified regulation and controlled regulation) positively influenced conceptual counting, and negatively influenced number concept. This means that students with MD substantial motivation result in comparatively higher conceptual counting score and less number concept scores. It is plausible that children with MD who take conceptual counting got learning using gabat'a as an instructional aids and a game do well in school might come to enjoy learning, feel capable of taking on challenges, and like to master the material independently as a result of receiving high marks and positive feedback. These children got hands of experience of counting using gabat'a with the beads for cardinality, one to one correspondence, and stable order. However, at the time of number concept instruction, children dominantly learn number symbol identification and quantity discrimination.

A canonical correlation analysis was also performed between the early mathematics motivation subscales and the arithmetic achievement subscales. Cut off correlations of 0.30 were used for interpretation of the canonical variates (Tabachnick & Fidell, 2012). A significant relationship was not found between motivation subscales (intrinsic motivation, identified regulation and controlled regulation) and the arithmetic subscales (dot addition , symbolic addition, dot subtraction and symbolic subtraction). This result is in contrary with plenty number of studies in different context. However, the present study argued that a non significant result was found since playing the board game may not enjoyable for first graders with MD because the game might be so challenges exceeding players' skills. So, when students don't enjoy learning, they are less likely to show interest, value in, and effort toward achievement, and more likely to perform poorly.

5.1.4. Implications of the Study

Based on the results of the present study , and the recommendations of other researchers (Agrawal & Morin, 2016; Powell, 2015), the CRA instructional framework with explicit instruction using gabat'a entails the implications, including application in special education intervention, the instructional aids organization, the instructional design, implementation of the intervention lessons, and curriculum trajectory and policy making. It is uncovered as follows,

Application in Inclusive Classroom. It should be put into consideration for use in elementary and beyond mathematics classrooms as an inclusive education intervention to help students with learning disabilities to develop conceptual understanding along with skill development of mathematics, particularly mathematics related CNC concepts to operations. It is possible to expand the implementation of the CRA instructional framework with explicit instruction using gabat'a to populations beyond students with disabilities. A plausible extension is the use of this instructional strategy to students who have not yet been identified with a learning disability but are receiving special educational services and interventions. Besides, this strategy can serve for all students involving elementary general education teachers implementing within their mathematics classes. .

Designing Differential Instruction. Within the mathematics instruction, utilizing the CRA instruction with gabat'a provides teachers an opportunity to differentiate. Within the CRA instructional strategy in an individualized and systematical manner, teachers differentiate using concrete, representational, and abstract teaching. However, most of the regular 4 school teachers encounter challenges to pass from one phase to another. This means that some students are very skillful and pass into the representational phase. But, the rest of the students can stay in the concrete stage. Eventually, step by step, they can pass to the last stage without the use of objects or drawings.

Training to All Preserves Special Education Teachers. It is pertinent to train CRA instructional framework with explicit instruction using gabat'a to pre-service special education experts to implement for students with disabilities. Experts in special education need to work to integrate CRA instructional strategy as the part of instruction and field practice into their mathematics methods curriculum for special education.

Instructional Aids Organization. The first grade mathematics teachers together with the school pedagogical centers can prepare gabat'a from simple local materials such as wood, beads/ stones and some other materials. It is cheap cost and possible to organize using local materials or by pitting 12 holes with two stores on the ground then dividing into two equal parts vertically for instructional purpose and combining them to suit for pair playing as well.

The Instructional Design and Implementation of the Intervention Lessons. The lessons followed best practice for explicit instruction and the CRA teaching sequence using gabat'a emphasized arithmetic. Based on the sequence, the mathematics teacher could do the routine in the following ways; first, the teacher should arrange the gabat'a with beads or stones. Half part of the gabat'a should be distributed for each students and let the students to put all the beads in the hole of the store. The teacher writes the addition problem on the board in dots with their corresponding numbers. Then for horizontal addition, the students put the beads with their corresponding number on the upper or lower row and taking them on the third hole to sum all. Whereas for the subtraction, taking beads from the subtrahend hole and counting the remaining beads gives you the result. Second, during the representational stage of instruction, a routine was drawing physical gabat'a mentally putting all the important contents, such as six holes, beads, and corresponding numbers on paper. Then, like the physical gabat'a, the students draw dots in the first and second holes. Draw again all dots from the two holes together onto the third hole and count them all to get the sum. For the case of subtraction, simply from the subtrahend hole and making cross (x) and counting the remaining uncrossed dots gives the result. Third, during the abstract stage of instruction, mathematics teacher used the additional teaching enhancement of min-counting strategy and verbal counting strategy.

Curriculum Trajectory and Policy Making, CRA technique using gabat'a makes students with MD to have hands of experience of touching objects of the physical gabat'a at a concrete level, and counting the dots and points using mental gabat'a, and finally they learn how to add and subtract numbers on paper. Then, using gabat'a, it can provide kinesthetic, auditory, visuo-spatial, and temporal cues on CNC and arithmetic. This research differentiates that CRA methods using gabat'a as instructional aid more helpful than using as a game for arithmetic development of the child with MD and suggests a curriculum trajectory based on children's development of arithmetic. CRA methods using gabat'a is enormously useful for students with MD in far rural areas of Ethiopia and other countries since gabat'a can be made out of local materials or simply arranging gabat'a by pitting six small holes on the ground and putting four small stones in each hole. In the Ethiopian context, encouraging the incorporation of the indigenous knowledge systems in the learning of mathematics is important. Using the indigenous math games such as gabat'a in this case is, therefore, important for putting government policy into practice.

5.1.5. Limitations and Future Direction

The followings are limitations that needed to be considered for this study. The first limitation of this study was the small number of students with MD involved in this study. Apparently, this is a common challenge when conducting randomized experimental studies involving students with learning disabilities due to the fact that only about 5% to 10% of school-age children are usually identified as having mathematics disabilities (Fuchs et al., 2008). The generalization of the results across settings is the second limitation of the study, the present study is conducted in small settings of the governmental schools, and it is obscure whether the same effects happen in another settings. A third limitation involves the lack of generalization of some student performance to mathematics skills and concepts assessed by proximal measures, particularly for the younger cohort. Students receiving CRA instruction using gabat'a are almost receiving arithmetic instruction within 20. It is pretty difficulty to generalize to more widespread skills. Thus, supplemental mathematics interventions should perhaps have a combined focus, one that examines more widespread mathematics content, while building foundational skills that are prerequisites for more complex skills and concepts taught in the core curriculum. A fourth one, the present study intervention time-line was set to 18 weeks. For CRA arithmetic, three sessions per week, 60 minutes per session for experimental group 1, 45 minutes per session for experimental group 2 were set, and 45 minutes per session for control group. But, for CRA CNC, there was no gabat'a game, both groups CIGO and control group spent equal 45 min. This time frame is organized based on similar experimental studies ranging from 12 to 22 weeks which varies in terms of time per session, sessions per week, and early numerical program (Fuchs et al., 2005; Asfaw, 2015; Jitendra et al., 2007; & Jitendra et al., 2013). However, it was faced a challenge to cover all the elements of contents with the present study intervention periods. This suggests that future studies should be more comprehensive and implemented for a longer period of time in order to enhance the likelihood for significant effects.

Future research with larger samples may provide more definitive evidence regarding the long-term effects of CNC and arithmetic interventions using gabat'a. The connecting of CRA method is a sequence from concrete to representational to abstract. This method has been effective. However, CRA instruction using gabat'a has alternative ways of teaching apart from this connection. That is, teaching concrete to abstract and representation to abstract methods needs to be researched for the future. It is plausible also to continue to explore the CRA with explicit instructional strategy using gabat'a, for students with other disabilities for whom this instructional framework could be beneficial (e.g., students with visual impairment, mild intellectual disability, and autism spectrum disorder). More researches on the other areas of mathematics apart from CNC and arithmetic, such as multiplication, division and etc., are also needed on the CRA instructional framework using gabat'a.

5.2. Conclusion

The concrete fading early numeral instructional intervention utilizing gabat'a program was designed to foster CNC, arithmetic skills and early mathematics motivation performances of grade one children with MD. This indigenous gabat'a can be made out of local materials and easily accessible to schools and home This material has dual uses as an instructional aid and a game without losing its cultural value. Utilizing it as an instructional aids played a role for enacting CRA instructional strategy with explicit instruction. The findings from this study were encouraging in a sense that the concrete fading early numeral instructional intervention utilizing gabat'a program seems to yield better outcomes in students' with MD performance in CNC , arithmetic and early mathematics motivation. This study also adds to a small in the growing body of literature suggesting about the inconsistent invaluable differences in term of gender, difficulty type and PMK in children's responsiveness to early CNC and arithmetic interventions, and early mathematics motivation.

. Therefore, CRA methods using gabat'a is enormously useful for students with MD. Putting this as an input, further investigation is deemed necessary to make this strategy to be the part of the curriculum and used as both for playing the game and teaching elementary mathematics concepts.

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Appendices

Appendix A

***Screening scale (student's assessment and support for students with SNEds in primary Schools*)**

This screening tool is taken from MoE of Ethiopia from the document of student's assessment and support for students with SNEds in primary Schools. This scale is filled by the home room and subject teachers who know the student very well. The scale has description of each item.

Screening scale of reading difficulties

No	Items	Not(1)	Yes observed(2)
1	Difficulty identifying randomly assigned letters		
2	Difficulty randomly listing the selected letters on a page (መ ቢ ሠ ኹ ጠ……)		
3	Making errors (substitution and ignoring letters)		
4	Difficulty learning and remembering letter names		
5	Difficulty matching letters and the sounds they represent		
6	Difficulty on word reading		
7	Slow to acquire new reading vocabulary, despite repeated exposure		
8	Has difficulty tracking and often loses his/her place while reading.		
9	Recognizes a word in one sentence (or paragraph or page) but not the next		
10	Difficulty pronouncing multi-syllabic words when reading (may omit syllables, or switch order); and (often) difficulty reading/saying the word even when corrected		
11	Once a reading mistake is made, often repeats that mistake over and over, as if it were an earworm (tune stuck in the head)		
12	Pronounced difficulty remembering high-frequency irregular words (e.g., said, the, where, of; does; could)		
13	Substitutes prepositions, articles, and pronouns (e.g., of/for, the/a, his/her) or omits them entirely.		
14	Changes verb endings (e.g., reads bring/brings; happened/happening)		

Screening scale of mathematics difficulties

No	Items	Not observed	Yes observed
1	Slow to develop number related skill. (concept of high and low, long and short,		
2	Difficulty to organized object in order (from the smallest to the biggest, from the tallest to the shortest……..)		
3	Has trouble recognizing numbers and symbols(::, 12) or (the four operation etc)		
4	Challenge in calling numbers sequentially (1,2,3,4…. Or 10,20,30…. Or 5,10,15… or on number line -2,-1,0,1,2)		
5	May often use fingers to count number, especially in grade 2 or more since beginners in grade one can be tolerated		
6	Difficulty to estimate number quantities (Visualizing small or large quantity…)		
7	Poor sense of direction		
8	Forget correct number tasks which was performed earlier		
9	Difficulty in money changes and values		
10	Challenges using mathematical operational signs; adding, subtracting, multiplying, and division(2+2, 2-2, 2/2, and 2*2)		
11	Difficulty calling randomly presents numbers (6, 8, 11, 22, 45…)		
12	Discomfort with all sorts of number related activities		
13	Show difficulty understanding concepts when adding, subtracting, multiplying, or dividing (--+5=10) or (10-5=---)		
14	Had difficulty understanding concepts related to time such as days, weeks, months……		
15	Has difficulty understanding and doing word problems		

Screening scale of writing difficulties

No	Items	Not observed	Yes observed
1	Has trouble holding writing tool properly		
2	Appear with old wrist or body position while writing		
3	Turn paper position inappropriately while writing		
4	Involve in excessive erasures		
5	Show inconsistent letter slant		
6	Letter or word omission		
7	Irregular letter sizes		
8	Irregular letter shapes		
9	Misuse of line when writing		
10	Misuse of margin of the page		
11	Poor organization on the page		
12	Inefficient speed in copying		
13	Many misspelled words		
14	Heavy reliance on vision with very close distance		
15	Difficulty getting started on writing assignments		
16	Many errors		
17	Exhausting quickly while writing		
18	Uneven spacing between letters and words		
19	Difficulty with sentence structure and word order		
20	General illegibility		

Screening scale of behavioral challenges

Externalized (E) and internalized (I) behavioral challenges

No	Items	Not (1)	Yes observed(2)
1(E)	Aggressiveness		
2(E)	Damaging of school property		
3(E)	Often fighting with teachers and peers		
4(E)	Temper tantrums		
5(E)	Attention seeking by disturbing or biting peers, developing feeling of superiority		
6(E)	Often negatively affect others by disturbing teaching and learning activities		
7(E)	Hyperactive		
8(E)	Poor attention		
9(E)	Act out their feeling and emotion		
10(I)	Depression		
11(I)	Anxiety		
12(I)	Loneliness and social withdrawal		
13(I)	Feeling of inferiority		
14(I)	Hypersensitivity		
15(I)	Act in their feeling and emotions		
16(I)	Chewing finger nails, pen, cloth….		

Screening Scale of Intellectual challenges

Mild/ low intellectual challenges (MI) and increased level of intellectual challenge (II)

No	Items	Not (1)	Yes observed(2)
1(MI)	Often forget lesson taught the next day		
2(MI)	Tend to forget doing home work or assignment		
3(MI)	Forget concepts or event presented unlike their grade mate		
4(MI)	Often make error/wrong answer on tasks		
5(MI)	Shows close similar difficulty levels in most subject areas		
6(MI)	Tend to shows dependence on peers for academic assistance		
7(MI)	Appear to have better performance on non academic tasks		
8(MI)	Below average performance in most subject areas		
9(MI)	Gradually develop behavior problem due to low academic performance		
10(MI)	As they get less attention due to low academic achievement seek attention by distributing in the classroom		
11(II)	Shows clumsiness on physical appearance		
12(II)	Poor eye-hand coordination		
13(II)	Poor gross-motor coordination		
14(II)	Poor fine motor movement		
15(II)	Difficulty to understand contents for the grade level		
16(II)	Difficulty to develop reading and writing skill		
17(II)	Often uncoordinated gross motor and may fail		
18(II)	Slow language development, limited vocabulary		
19(II)	Articulation error during speech production		
20(II)	Increased forgetfulness on lesson learned		
21(II)	Delay in mastery daily living skill; toileting, eating, dressing, personal hygiene, awareness of family, keeping learning materials properly…..		
22(II)	Poor imitation skills		

Appendix B

Screening test (BANUCA test)

BANUCA test is organized by MoE of Ethiopia. This test is set up for the sake of screening students with mathematics difficult for dissertation purposes. Students with mathematics difficulties via the guidance of the data collector will do all the questions. The test manual is in two versions, Amharic and English that guides the data collector. But the questions are Arabic numbers, therefore no need to translate to Amharic. The tools, instructions and timing are based on the Banuca manual

Tools needed: A pencil and a stopwatch (or a clock with second hand)

General Instruction: The examiner, cautiously, follow the subsequent instructions:

1. The examiner controls how the examinees do the tasks. They are not allowed to proceed at their own speed from task to task; they have to wait for the next instructions before proceeding.
2. Make sure that the examinees follow the instructions. If you notice that some of the examinees did not understand the instructions, repeat them slower and show carefully the purpose of the task using the example items.
3. Lead the examinees in completing the personal details on the front cover of the test
4. Examiner says to the examinees, Very good, now put your pencil on the table and turn next page, when the time is over.

Timing:

Task 1: Dot Comparison**: max 3 minutes** (if everyone is ready earlier, continue to the next task)

Task 2: Single Digit Addition**፡ max 4 minutes**

Task 3: Correspondence**፡ max 4 minutes**

Task 4: Single Digit Subtraction: **max 4 minutes**

Task 5: Writing numbers: Number Line: **max 4 minutes**

Task 6: Number Comparisons: **max 4 minutes**

Task 7: Matching Spoken and Written Numbers: **Give examinees 20 seconds time for each item.**

Task 8: Multi- Digit Calculations**: 6 minutes**

Task 9: Arithmetic Reasoning**: max 8 minutes**

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BANUCA

BASIC NUMERICAL AND CALCULATION ABILITIES

Child ID

NAME	
GENDER	Girl ☐ Boy ☐
GRADE	1 ☐ 2 ☐ 3 ☐ 4 ☐
AGE	YEARS

LANGUAGE	☐ Amharic ☐ Afan oromo
DATE of BIRTH	YEAR MONTH
FAMILY	M&F ☐ M ☐ F ☐ NO ☐
SCHOOL	
CITY	
TYPE	U ☐ S ☐ R ☐
DATE	
RESEARCHER	

	TOTAL SCORE	SHORT-FORMS Number skills	Arithm. Skills
Dot Comparison	6	6	
Addition	8	8	8
Correspondence	6	6	
Subtraction	8	8	8
Numberline	8	8	
Number Comparison	10		10
Spoken Numbers	8		
Calculations	10		10
Arithmetic Reasoning	15		
TOTAL	79	36	36

NOTES:

EXPERIMENTAL VERSION FOR RESEARCH PURPOSES - MINISTRY OF EDUCATION - ETHIOPIA

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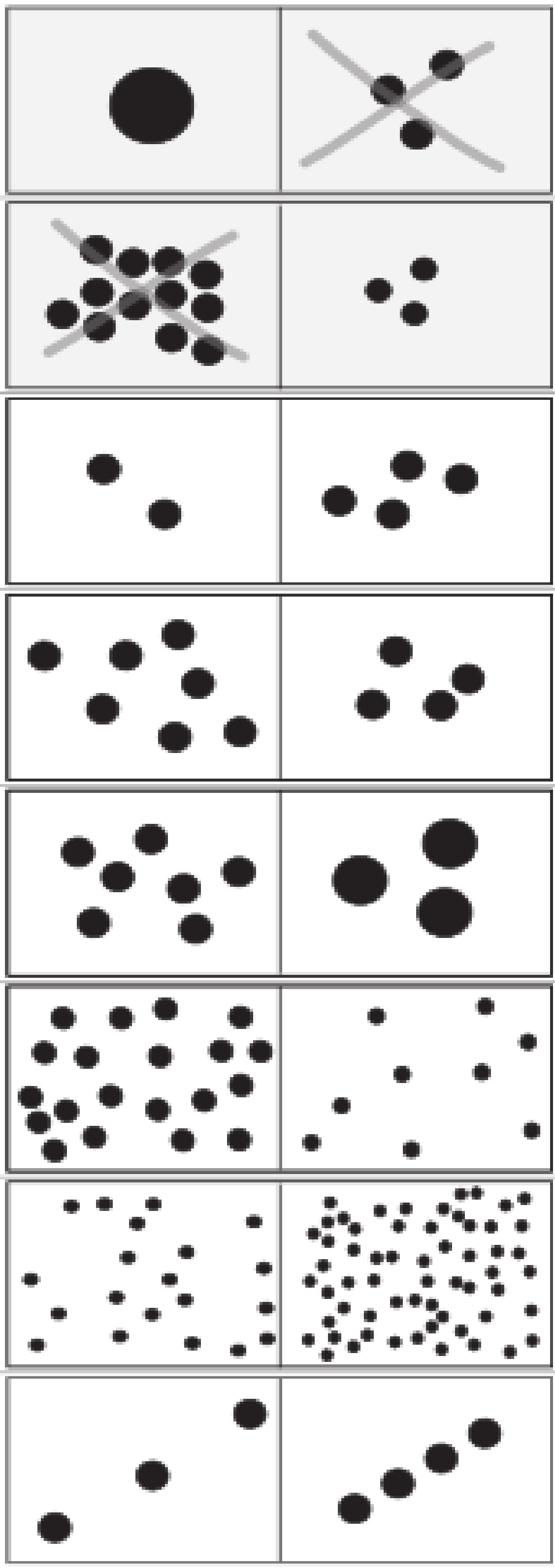

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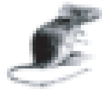

2 + 1 = 3

1 + 9 = 10

2 + 3 = ____

3 + 4 = ____

2 + 7 = ____

5 + 3 = ____

6 + 5 = ____

2 + 9 = ____

7 + 6 = ____

9 + 7 = ____

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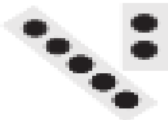
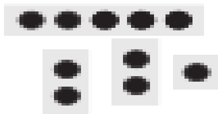
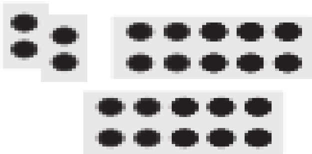
	4	~~2~~
	11	1
	7	212
	23	~~5~~
	5	4
	22	14
	55	9
	10	46
	7	232
	52	6
	352	82
	13	10
	351	80
	18	53
	42	24
	204	31

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2 – 1 =	1
5 – 1 =	4
3 – 2 =	
7 – 4 =	
9 – 2 =	
8 – 5 =	
14 – 4 =	
11 – 8 =	
15 – 6 =	
13 – 7 =	

/8

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2	3	4
5	6	
9	10	
18	19	
38	39	
53	54	
98	99	
258	259	
1470	1471	

/8

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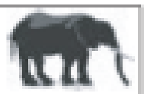

2	4	1	3
2	3	7	6
11	9	6	3
14	17	11	9
19	27	31	22
46	60	57	18
24	114	96	78
411	297	108	87
536	546	456	365
1202	1021	1089	1119
6789	12345	6708	10067

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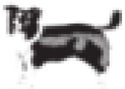

	2	4	8	12	21
A	25	9	6	1	14
B	28	88	180	18	16
C	22	19	61	25	35
D	703	713	37	307	73
E	200	1200	1002	102	2100
F	5004	54	405	0540	504
G	40012	4012	4120	400012	412000
H	10004	100004	104	104004	104000

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2	–	1	=	1
2	+	3	=	5
10	+	15	=	
18	–	10	=	
28	–	20	=	
37	+	20	=	
100	–	10	=	
	–	4	=	2
100	+	104	=	
502	–	498	=	
6608	–		=	600
	–	805	=	2020

/10

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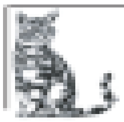


1	2	3		6	4	8	3
2	4	6		8	5	7	0
5	4	3		1	10	2	0
7	8	9		6	10	12	13
5	10	15		1	25	20	18
3	4	5		8	6	4	7
18	17	16		11	51	5	15
30	45	60		85	66	75	70
27	28	29		21	13	210	30
62	51	40		31	20	73	29
3	6	9		10	12	15	7
97	98	99		100	101	110	109
3	5	7		14	10	8	9
20	16	12		8	4	2	1
28	21	14		0	7	10	8
8	11	14		35	22	17	16
9	7	5		2	1	3	4

/15

Appendix C

Early Achievement Test: counting and number concept

The counting and number concept achievement test was organized with cooperation of first grade mathematics elementary teachers as previously mentioned. This test includes oral counting, missing number, cardinality, one to one correspondence, stable order, number identification, and quantity discrimination. The content validity was evaluated by three PhD students, two from mathematics, and one from measurement and evaluation.

Tools needed: A pencil and a stopwatch (or a clock with second hand)

General Instruction: The examiner, cautiously, follow the subsequent instructions:

1. The examiner controls how the examinees do the tasks. They are not allowed to proceed at their own speed from task to task; they have to wait for the next instructions before proceeding.
2. Make sure that the examinees follow the instructions. If you notice that some of the examinees did not understand the instructions, repeat them slower and show carefully the purpose of the task using the example items.
3. Lead the examinees in completing the personal details on the front cover of the test
4. Examiner says to the examinees, Very good, now put your pencil on the table and turn next page, when the time is over.

Timing:

Task 1: Dot Oral counting (OC) : max 1 minute

Task 2: Missing Number (MN) : Untimed

Task 3: One-To-One Correspondence (OTO): max 1 minute

Task 4: Cardinality (C): Untimed

Task 5: Stable order (SO) :Untimed

Task 6: Number identification (NI):: max 1 minute

Task 7: Quantity Discrimination (QD): Untimed

Counting and Number concept

NAME	
GENDER	Girl ☐ Boy ☐
GRADE	1 ☐ 2 ☐ 3 ☐ 4 ☐
AGE	YEARS

	TOTAL SCORE		
Oral Counting	30		30
Missing number	40		40
Cardinality	9		9
One to one Correspondence	30		30
Stable order	19		19
Number Identification	30	30	
Quantity discrimination	10	10	
TOTAL	168	40	128

LANGUAGE	☐ Amharic ☐ Afan oromo
DATE of BIRTH	YEAR ☐☐ MONTH ☐☐
FAMILY	M&F M F NO
SCHOOL	
Prior class	KG Yes ☐ No ☐
Difficulty type	MD ☐ MDRD ☐
RESEARCHER	

NOTES

This test is organized for dissertation purposes

Give this instruction of the child by SAYING: In this section, make yourself ready to count, starting from one to thirty i.e. ONE, TWO, THREE………..

You should begin counting when I say **“BEGIN”** and stop when I say **“STOP”**. Count as fast as possible. Is it clear? Are you ready to begin counting? Good, begin.

Oral counting

RECORD:

Remaining time on the stopwatch:___________________

Last number child counted correctly:___________________

Missing numbers

1) Couning forward till 30

1	2	3	**4**	5
6	7	8	9	
	12	13		15
16		18		20
21	22			25
	27	28	29	

2) Counting backward till 30

30	29	28	**27**	26
25		23	22	
	19		17	16
15	14	13		11
10		8		6
	4	3	2	

3) Counting in forward in twos

2	4	6	**8**	10
12		16	18	
	24		28	30
32		36		40
42		46		50
	54	56	58	

4) Counting in backwards in twos

30	28	26	**24**	22
20		16		12
	8	6	4	

5) Counting in forward in fives

5	10	15	**20**	25
30		40	45	

6) Counting in backwards in fives

50	45	40	**35**	30
25		15	10	

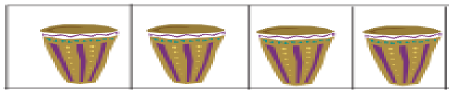
7) Counting in forwards in tens

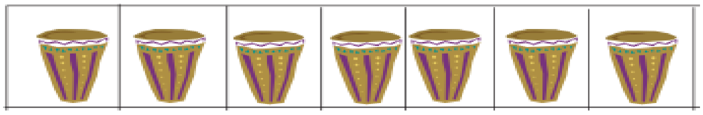
10	20	30	**40**	50
60		80	90	

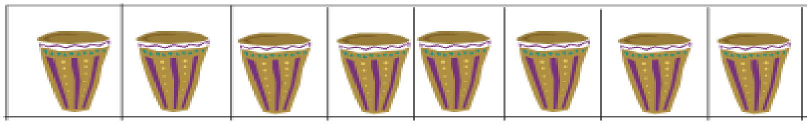
8) Counting in backwards in tens

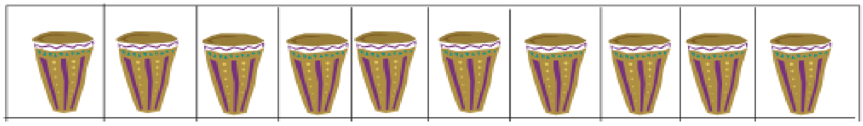
100	90	80	**70**	60
50		30	20	

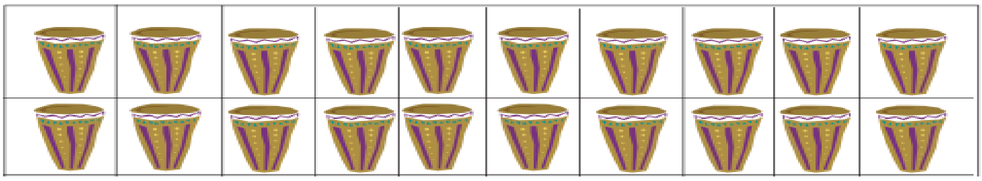
Cardinality

a)  **4**

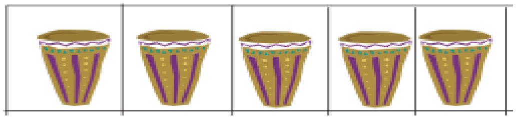
b)  --------

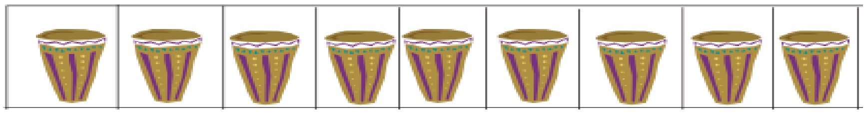
c)  --------

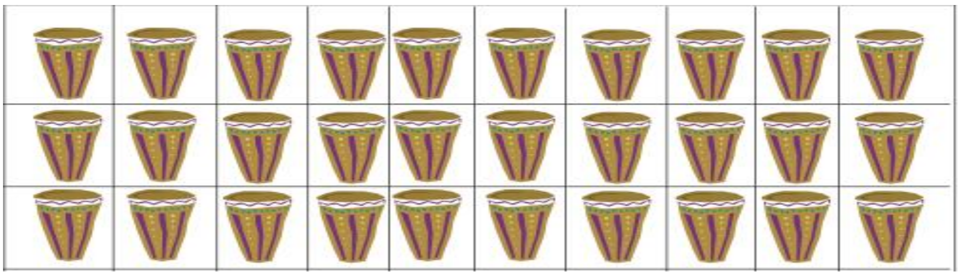
d)  --------

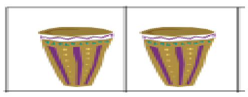
e)  -------

f)  -------

g)  --------

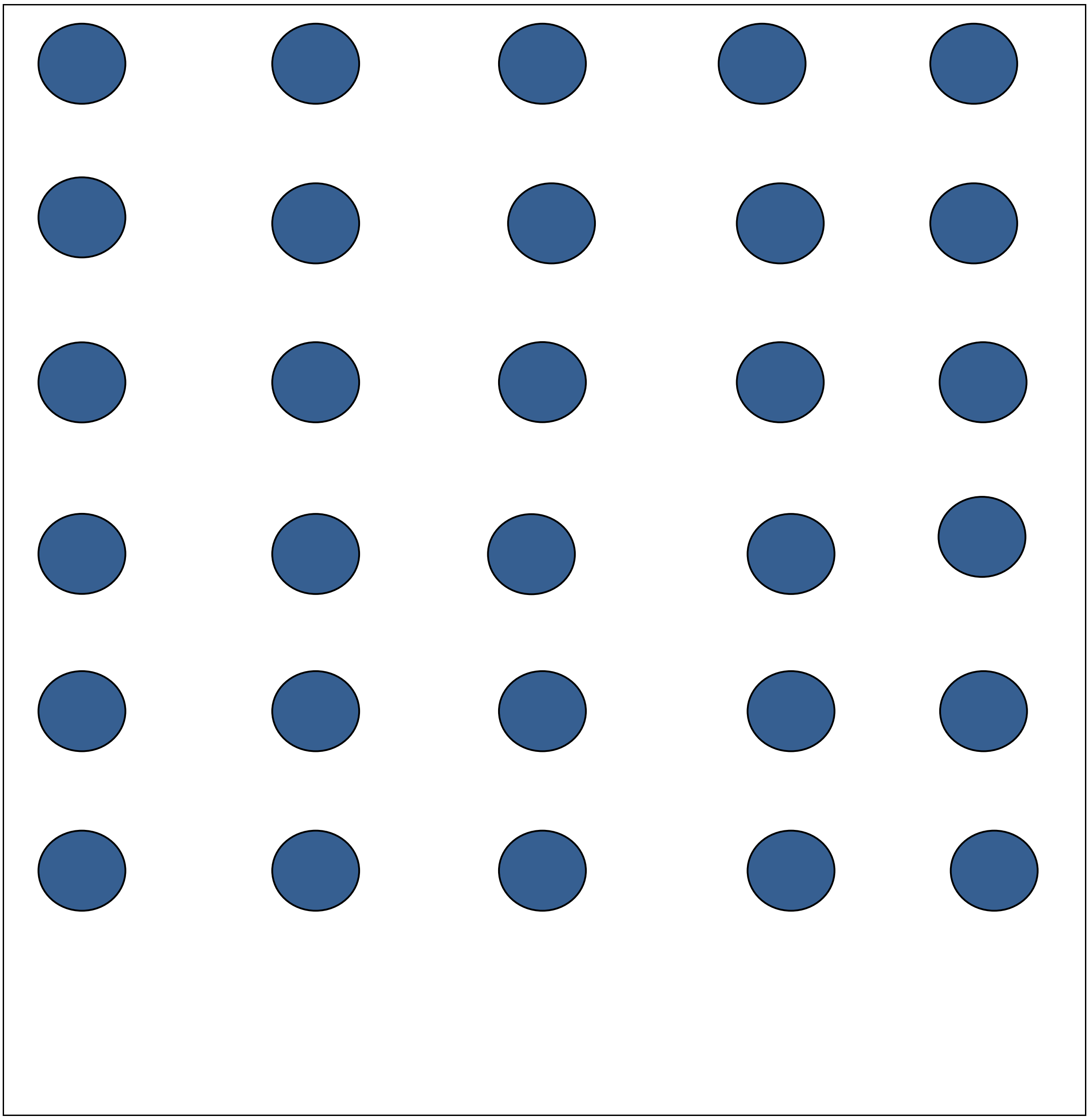
h)  -------

i)  ---------

j)  -------

One to one correspondence

Count all circles:



Remaining seconds on the stopwatch: ________________

Last number Child counted correctly

____

Stable order

Random ordered number	Counting order
5	1
18	
3	
14	
9	
1	
15	
10	
16	
2	
20	
4	
19	
6	
12	
8	
13	
17	
7	
11	

1	**17**	**3**	**19**	**5**
6	**11**	**8**	**27**	**10**
7	**12**	**24**	**14**	**15**
16	**2**	**18**	**4**	**25**
21	**29**	**23**	**13**	**20**
26	**9**	**28**	**22**	**30**

Time left on the stopwatch (in seconds): …………….

Quantity discrimination

Circle the bigger number

1.	6____________ 9
2.	22 ____________12
3.	5______________7
4.	1______________6
5.	12_____________13
6.	8______________18
7.	3______________4
8.	2______________18
9.	10_____________9
10.	11_____________19
11.	14_____________16
12.	20_____________15

Appendix D

***Early Achievement test:* Arithmetic**

Like the previous counting and number concept test measure, the arithmetic achievement test was set by the same teachers. This test includes addition (dot and symbolic) and subtraction (dot and symbolic).Validity of the test was checked by the same experts as in CNC. These experts confirmed the adequacy of the content validity, wording, and response format

Tools needed: A pencil and a stopwatch (or a clock with second hand)

General Instruction: The examiner, cautiously, follow the subsequent instructions:

1. The examiner controls how the examinees do the tasks. They are not allowed to proceed at their own speed from task to task; they have to wait for the next instructions before proceeding.
2. Make sure that the examinees follow the instructions. If you notice that some of the examinees did not understand the instructions, repeat them slower and show carefully the purpose of the task using the example items.
3. Lead the examinees in completing the personal details on the front cover of the test
4. Examiner says to the examinees, Very good, now put your pencil on the table and turn next page, when the time is over.

Timing:

Arithmetic operation task was not timed and scoring was about the count of right responses out of the total items attempted.

Arithmetic

NAME	
GENDER	Girl ☐ Boy ☐
GRADE	1 ☐ 2 ☐ 3 ☐ 4 ☐
AGE	YEARS

		TOTAL SCORE	Addition skills	Subtraction Skills
Dot Addition		15	15	
Symbolic Addition		15	15	
Dot Subtraction		15		15
Symbolic Subtraction		15		15
	TOTAL	60	30	30

LANGUAGE	☐ Amharic ☐ Afan Oromo
DATE of BIRTH	YEAR MONTH
FAMILY	M&F ☐ M ☐ F ☐ NO ☐
SCHOOL	
Prior class	KG Yes ☐ No ☐
Difficulty types	MD ☐ MDRD ☐
RESEARCHER	

NOTES :

This test is organized for dissertation purposes

Session 1: Addition

Material needed: Question sheet

Instructions:

1. Give the question paper to the child. Ask the child to open **the sheet.**

2. For each part of the questions, time is allotted.

3. **Stop Rule:** Stop the child if s/he misses the first four consecutive questions.

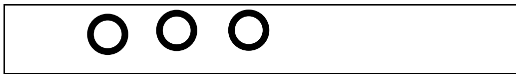
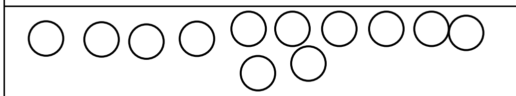
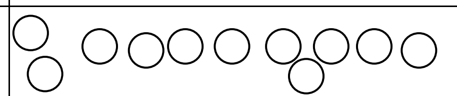
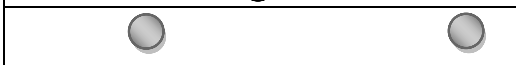
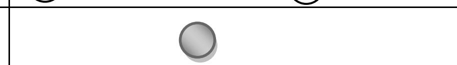
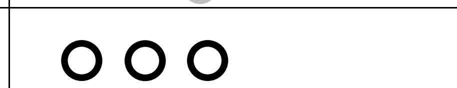
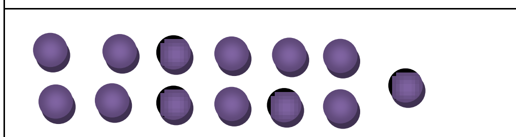
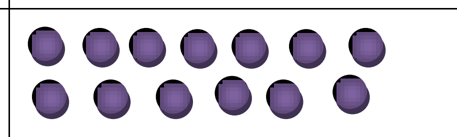
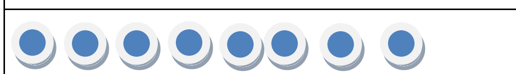
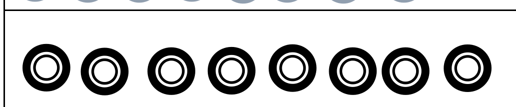
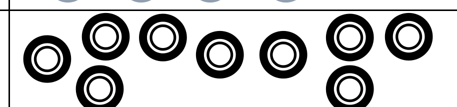
4. **Scoring:** Enter the child‘s response on the space provided for each item.

Say to the child: Here are addition problems, telling the child to sum the numbers. That is, answer the question: **How much is …?** Let the child to enter answers in the space provided. If the child does not respond, for four consecutive questions, tell them you will stop the child.

You can use pencil/pen and paper to find the sum. Here are some of the examples.

Example: (A) 4 + 2 = ___ (6) (B) 11 + 9 = _____ (20)

Adding single, double digits within 30 without carrying over (Dot Addition)

	+		=	5
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	
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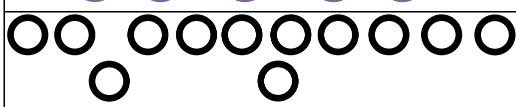
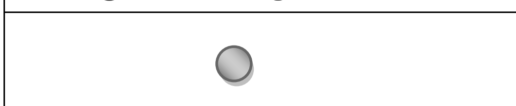
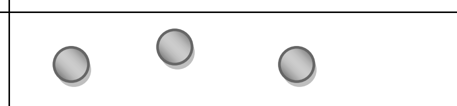
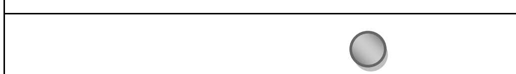
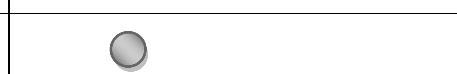
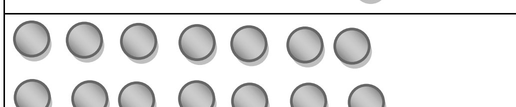
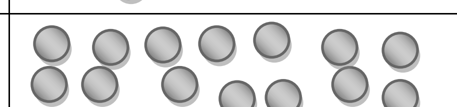
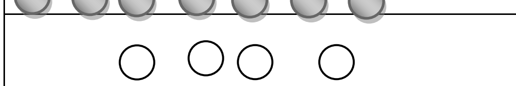
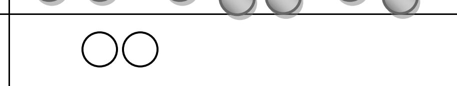
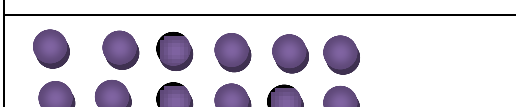
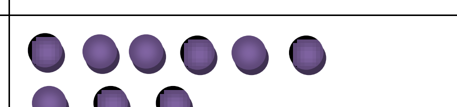
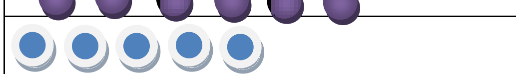
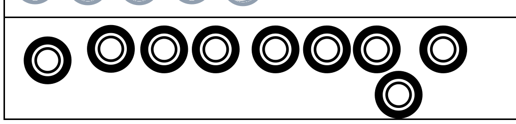
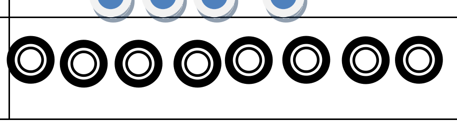
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	
	+		=	

Adding single, double digits within 30 without carrying over (Symbolic Addition)

3	+	**7**	=	**10**
2	+	**4**	=	
5	+	**6**	=	
1	+	**8**	=	
2	+	**1**	=	
12	+	**7**	=	
8	+	**17**	=	
6	+	**14**	=	
20	+	**7**	=	
13	+	**4**	=	
7	+	**16**	=	
15	+	**1**	=	
18	+	**11**	=	
2	+	**5**	=	
1	+	**4**	=	
8	+	**6**	=	

Subtracting single, double digits within 30 without carrying over (Dot Subtraction)

	-		=	1
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	
	-		=	

Subtracting single, double digits within 30 without carrying over (Symbolic subtraction)

7	-	3	=	4
5	-	4	=	
13	-	5	=	
8	-	2	=	
15	-	6	=	
6	-	2	=	
18	-	7	=	
16	-	2	=	
21	-	2	=	
29	-	8	=	
30	-	1	=	
19	-	3	=	
22	-	4	=	
27	-	3	=	
28	-	2	=	
26	-	4	=	

Appendix E

Early Mathematics Motivational Scale

This test is set up as pretest and posttest for dissertation purposes. The motivational scale is a questionnaire designed to identify those situations in which an individual is likely to have a particular interest. From this information, more informed decisions can be drawn concerning the selection of appropriate intervention or treatments. This will be filled by the students with mathematics difficulties via the guidance of the data collector. The test is in two versions, Amharic and English. The data collectors, cautiously, follow the subsequent instructions:

1. Make sure that the child understands the instruction during filling of the scale.
2. Follow each student whether they fill out the form properly.
3. Read instruction slowly but aloud for the child.

Rating

Rate each item in each of the three categories ("I" = Intrinsic motivation; "IR"= Identified regulation; "C"= Controlled regulation.

Child's Code number

____

Put a number before each behavior:

0 = no ; 1 = sometimes; 2 = always

1(I) ______Topics in mathematics are interesting for me.

ለኔ የሒሳብ ት/ት ርዕሶች ይመቹኛል።

2(I) _____I would like to raise my hand in mathematics class.

በሒሳብ ት/ት ክ/ጊዜ እጄን በማውጣት ተሳትፎ ማድረግ እወዳለሁ።

3(I) _____ I am happy when I am successful in mathematics class.

በሒሳብ ት/ት ስኬታማ ስሆን እደሰታለሁ።

4(I) _____Mathematics is an easy subject for me.

የሒሳብ ት/ት ለኔ ቀላል ነው።

5(I) _____ I would like to participate in different activities in mathematics class.

የተለያዩ የሒሳብ ት/ት አክቲቪቲዎችን ተሳትፎ ማድረግ እወዳለሁ።

6(I) _____ Engages in mathematics activities after assignments are completed.

የሒሳብ ት/ት አክቲቪቲዎችን አሳይመንት ከጨረስኩኝ በኃላም እሰራለሁ።

7(I) _____I like finding more than one solutions to mathematics problems.

በተለያዩ መንገዶች የሒሳብ ት/ት ጥያቄዎችን መስራት እወዳለሁ፡፡

8(I) _____ I am interested to work on un-graded mathematics tasks.

የሒሳብ ት/ት ጥያቄዎችን ማርክ ባይያዝላቸውም መስራት እፈልጋለሁ፡፡

9(I) _____Challenging mathematics problems initiates me to solve them.

ከበድ ያሉ የሒሳብ ት/ት ጥያቄዎችን መስራት ያስደስተኛል፡፡

10(I) _____ I become more willing to learn new topics while learning current math topic.

አዲስ የሒሳብ ት/ት ርዕስ ሲጀመር የመማር ፍላጎቴ ይበልጥ ይጨምራል፡፡

11(I) _____I repeat the topics I learned in mathematics class.

ክፍል የተማርኩትን የሒሳብ ት/ት ደግሜ እሰራለሁ፡፡

12(IR)____I can use the things that I learned in mathematics in daily life

የተማርኩትን የሒሳብ ት/ት በየቀኑ ለማደርጋቸው ነገሮች እጠቀማለሁ፡፡

13(IR)____I think that what I am learning in mathematics is necessary for my future.

የምማረውን የሒሳብ ት/ት ለወደፊቱ ይጠቅመኛል፡፡

14(IR)____I think that mathematics improves my intelligence

የሒሳብ ት/ት የኔን አስተሳሰብ አሻሽሎልኛል፡፡

15(IR)_____I can explain the things that I learned in my own words in mathematics subject.

የተማርኩትን የሒሳብ ት/ት በራሴ አባባል መግለፅ እችላለሁ፡፡

16(IR)____ I can explain what I learned in mathematics to others

የተማርኩትን የሒሳብ ት/ት ለሌሎች ማስረዳት እችላለሁ፡፡

17(IR)____I can explain reasons of the use of procedures while solving mathematics problems.

የሒሳብ ት/ት ጥያቄዎችን ስሰራ እያንዳንዱን ስቴፕ በምክንያት እገልፃለሁ፡፡

18(IR)____When I encounter challenges in math , seeks help.

የሒሳብ ት/ት ጥያቄዎችን በሚከብዱኝ ወቅት፤ ለመረዳት እጠይቃለሁ፡፡

19(IR)_______I Begin work on math tasks immediately.

የሒሳብ ት/ት ጥያቄዎች ሲሰጡኝ ወድያው እሰራለሁ፡፡

20(IR)_______Math lesson helps me to share my knowledge to the classmate.

የሒሳብ ት/ት ዕውቀቴን ለሌሎች ለክላስ ተማሪዎች ለማካፈል እረድቶኛል፡፡

21(IR)________I am aware of the benefits from what I've learned in mathematics subject.

የተማርኩትን የሒሳብ ት/ት ምን ያህል ጥቅም እንዳለሁ እረዳለሁ፡፡

22(C) ________I do maths to get grade from my teacher.

እኔ የሒሳብ ት/ት የምሰራው ጥሩ ውጤት ለማምጣት ነዉ፡፡

23(C) ________I do maths to get praise from my classmates.

እኔ የሒሳብ ት/ት የምሰራው የክፍል ጋደኞቼ እንዲያደንቁኝ ነው ፡፡

24(C) ________I do maths to get a nice reward.

እኔ የሒሳብ ት/ት የምሰራው ጥሩ ሽልማት ለማግኘት ነው፡፡

25(C) _________I do maths to please my parents or my teacher.

እኔ የሒሳብ ት/ት የምሰራው ወላጆቼን ለማስደሰት ነው፡፡

26(C) _________I do maths to show others how good I am.

እኔ የሒሳብ ት/ት የምሰራው ጥሩ ተማሪ እንደሆንኩኝ ለማሳየት ነው፡፡

27(C) _________I do maths to get a job for the future.

እኔ የሒሳብ ት/ት የምሰራው ለወደፊት ስራ ስለማገኝበት ነው፡፡

28(C) ________I do maths to get permission of playing a game.

እኔ የሒሳብ ት/ት የምሰራው የጨዋታ ጊዜ ፍቃድ ለመግኘት ነው፡፡

29 (C) ________I do math not to be punished by parents if I fail.

እኔ የሒሳብ ት/ት የምሰራው ከወደኩኝ ወላጅ እንዳይቀጣኝ ነው፡፡

30 (C) ________I do math to be competent in class.

እኔ የሒሳብ ት/ት የምሰራው በክፍል ውስጥ ተወዳዳሪ ተማሪ ለመሆን ነው፡፡

Appendix F

Checklist of Fidelity of Implementation

This checklist is prepared for assessing fidelity of implementation for dissertation purposes, encompassing adherence, exposure, quality of delivery of instruction, program specification, student's responsiveness, and reinforcement techniques. It is filled by math teacher and the school counselor who are the part of the intervention process.

Rating

Write yes if you agree and No if you are not for each item in a column.

Adherence	Yes/No	Remark
1. Learning objective(s) are met.		
2. Interventionist uses program materials effectively during instruction/ intervention.		
Exposure		
3. Sufficient amount of time devoted to instruction/ intervention		
Quality of Delivery of Instruction		
4. Interventionist appears adequately prepared to deliver instruction or intervention.		
5. Interventionist's interactions with students reflect encouragement and enthusiasm.		
6. Interventionist provides clear, explicit instruction for the child		
7. Interventionist provides positive, constructive feedback to the child.		
8. Pacing and transitions are effective.		
Program Specification		
9. Interventionist adheres to instructional components as designed		
10. Interventionist demonstrates knowledge of content and intervention strategy.		
Student's Responsiveness		
11. The student appears to be engaged		
Reinforcement Techniques		
12. Reinforcement Techniques are appropriate		

Appendix G

Consent Form

1. **Consent form (English version)**

I, in behalf of my child, undersigned the purpose of this study. I have been informed there is no harm. I have been informed that other people will not know my child results. I understand that there is a benefit to my child from the arithmetic intervention program. I have been told that participation in this study is voluntary and my child does not have to take part if I am not convinced and my child may refuse to be in the study. The study has been explained to me in the language I understand. I give consent to participate after a clear understanding of the objectives and conditions of the study.

Guardians' name ---

Relationship to participant: ---

Signature---------------------- Date: -----------------------

Data collector name: --

Signature: --------------------- Date: ---------------------------------

2. Consent form (Amharic version)

ስምምነቱ ማረጋገጫ ፎርም

እኔ ስሜ ከታች የተገ ፀዉ በጥናቱ ልጄ ተሳታፊ እንዲመሆን ስወስን የጥናቱን አላማዎች አሰራሮችና ቅድመ ሁኔታዎች በግልጽ በመረዳትና ከጥናቱ በልጄ ተሳታፊነት ፈቃደኛነቴን በማንኛዉም ደረጃ የማንሳት መብቴን በማረጋጥ ነዉ፡፡ እኔ -----------------------------በጥናቱ ልጄ ተሳታፊ እንዲመሆን በፊርማዩ እያረጋገጥሁ፡፡ ይህንን ስወስን በጥናቱ ሳቢያ ሉከሰቱ የሚችሉ ችግሮች በሚገባ የተረዳሁና ከጥናቱ በማንኛዉም ደረጃ ለመሰረዝ ብወስን አስገዳጅ ነገር አለመኖሩን እና ልጄም ከጥናቱ ተጠቃሚ መሆኑን በማመን ነዉ፡፡ እነዚህ መረጃዎች ሁለ በሚገባ በምረዳዉ ቋንቋ የተገለጸልኝ መሆኑን በፊርማዩ አረጋግጣሀሁ ፡፡

የወለጅ/ ያሳዳጊ ሙለ ስም---ፊርማ----------

የተመራማሪዉ ሙለ ስም፤ዶ/ር ኦቶ ወ/ሮ ወ/ት   ---------------------------------ፊርማ-----------

የምስከር ሙለ ስም --ፊርማ-----------

Appendix H

Brief Intervention Activities, Assessment, and Materials and Equipments in Each Sessions for Addition

Session	Intervention Contents	Interventionist's Activities	Student's Activities	Materials and Equipments	Assessment
S1	Terms, concepts and symbols of addition	Explaining terms and the symbol of addition Giving examples Concreting the concepts of addition using *gabat'a*	Following the explanation - Counting beads in two different holes & group them in one hole & count all beads as a sum.	- Addition symbols Beads in *gabat'a* and plastic number	Asking the symbols Asking questions by songs - Questions of commutative by *gabat'a*, symoblic (1+4=4+__) and non symbolic(mental *gabat'a*/dots)
	The procedure of addition	-Addressing the procedure of addition , by arranging *gabat'a* and showing beads in 2 holes that equals the sum	Adding using *gabat'a*	*Gabat'a* with beads and plastic number	
	Commutative property of addition	Showing using *gabat'a* by reversing the number of beads in different holes and the sum is the same.	Following the teacher Using gagata to add the beads in reverse order.	*Gabat'a* with beads and plastic number	
Adding single digit numbers					
S2	Adding zero to a number	Showing how to add zero to a number using various methods using *gabat'a*.	Adding zero using *gabat'a*	*Gabat'a* with beads and plastic number	Question like, 1+0, 1+1, and other by *Gabat'a* Mental *gabat'a* Symbolic
	Adding one to a number	Showing how to add one to a number using various methods using *gabat'a*.	Adding one using *gabat'a*	*Gabat'a* with beads and plastic number	
S3	Adding single digit numbers (sum not exceeding 10)	Portraying *gabat'a* technique Showing by taking all the beads in the two holes and put them all in one hole	Adding taking all the beads in the two holes and put them all in one hole	*Gabat'a* with beads and plastic number	>> also like 2+__=5
S4	Adding single digit numbers (sum, within 20)	>>	>>	>>	>>

S5	Adding two or more single digit number within 20	>> beads in three holes and put them all in one hole as a sum in *gabat'a*, MG, symbols	>> three holes and add them in one hole	>>	>>
S6	Adding two or more single digit number within 30	>> beads in three holes and put them all in one hole as a sum in *gabat'a*, MG, symbols	>> three holes and add them in one hole	>>	>>
Adding single digit numbers with two digits numbers horizontal and vertical without carrying over					
S7	Adding a two digit number to a one digit number without carrying over within 20	Showing how to add vertically w/o carrying over using *gabat'a*, MG, symbols	Practicing vertical addition using *gabat'a*, MG, symbols	>>	>>
S8	Adding a two digit number to a one digit number without carrying over within 30	Showing how to add vertically w/o carrying over using *gaba'ta*, MG, symbols	Practicing vertical addition using *gabat'a*, MG, symbols	>>	>>
S9	Adding a two digit number to another two digit number without carrying over within 30	>>	>>	>>	>>
S10	Solving simple daily life problems involving addition	Portraying some daily life addition problem, like shopping, money, time etc.	Solving problem related to daily activities	Money, watch etc	>>

Brief Intervention in Each Sessions for Subtraction

Session	**Intervention Contents**	**Interventionist Activities**	**Student's Activities**	**Materials and equipment**	**Assessment**
S1	- Terms, concepts and symbols of subtraction	- Explaining terms and the symbol of subtraction - Giving examples - Concreting the concepts of subtraction using *gabat'a*	- Following the explanation -Counting beads in one hole & subtract the number and the remaining is the result.	Subtraction - symbols - Beads in *gabat'a* and plastic number	- Asking the symbols - Asking questions by songs - Questions of Commutative by *gabat'a*, symoblic (1-4 ≠4-1) and non symbolic (mental *gabat'a* / dots) - Question like, 2-2, 3-3, & other by Gabat'a, - MG Symbolic
	- The procedure of subtraction	- -Addressing the procedure of subtraction , by arranging gabat'a and showing beads in 2 holes that equals the sum	- Subtract using gabata	- Gabata with beads and plastic number	
	- Subtracting a number from the same number	- Showing using gabat'a putting the same number in one hole and subtract different number beads re	- Following the teacher - Using gabat'a to subtract the beads from hole	- Gabat'a with beads and plastic number	
	- Learning subtraction is the reverse process of addition	>>	>>	>>	
Subtracting single digit numbers					
S2	Subtracting zero and one from a number	- Showing how to subtract zero and one from a number using gabat'a, mental gabat'a (MG), and symbols	- Subtracting zero or one using gabat'a	- Gabat'a with beads and plastic number	- Question like, 1-0, 3-1, and other by Gabat'a -MG Symbolic
S3	Subtracting a single digit with another single digit within 10	- Showing subtraction using *gabat'a*, MG, symbols	- Subtracting using *gabat'a*, MG, symbols	>>	>> also like 7-__=5
S4	Subtracting two or more single digit number within 20	>>	>>	>>	>>

Subtracting single digit numbers with two digits numbers horizontal and vertically					
S5	Subtracting a single digit numbers from two digit within 20	- Showing how to subtract horizontally and vertically using *gabat'a*, MG, symbols	-Practicing vertical and horizontal subtraction using *gabat'a*, MG, symbols	>>	>>
S6	Subtracting a one digit number from a two digit without borrowing within	>>	>>	>>	>>
S7	Subtracting a two digit number from a two digit without borrowing	>>	>>	>>	>>
S8	Solving simple daily life problems involving addition	-Portraying some daily life subtraction problem, like shopping, money, time etc.	- Solving problem related to daily activities	- Card Money, watch etc	

Appendix I

Teacher's guide for grade one mathematics

For this dissertation purpose, the contents, the objectives and the time of allocation for covering the instruction was considered**.**

ሒሳብ

፲ኛ ክፍል

የመምህር መምሪያ

አዘጋጅ፡-

ባይሳ ሰርቤሳ

አርታኢ፡-

ገብረየስ ኃይለጊዮርጊስ

ገምጋሚዎች፡-

ክፍሌ ይልማ

ዳኛው አስማረ

ምዕራፍ 1
እስከ 9 ያሉ የመቁጠሪያ ቁጥሮች

መግቢያ

በርካታ የትምህርት ባለሙያዎች እንደሚያብራሩት መቁጠር ለህፃናት የመጀመሪያ ትምህርት መሆን የለበትም፡፡ ከመቁጠር አስቀድሞ ነገሮችን በተለያዩ መስፈርቶች ለምሳሌ በቅርፅ ፣ በመልክ ወዘተ የመመደብ ልምምድ መምጣት ይኖርበታል፡፡ መቁጠር ቁጥርን ለመረዳት መነሻ ሊሆን ይችላል፡፡ ይህ ግን በራሱ በቂ ስለማይሆን ሕፃናት ቁጥርን በቀላሉ ለመገንዘብ እንዲችሉ ለማገዝ በቅድሚያ የቁጥሮችን ዋና ዋና ባህሪያት ማስረዳት ያስፈልጋል፡፡

ለምሳሌ በሁለት መጠኖች መሃል ያለዉን ዝምድና በማወዳደር ሕፃናት ብዛታቸዉን ማወቅ መቻል አለባቸዉ፡፡ ለዚህም በቂ ልምምድ እንዲያደርጉ ሁኔታዎችን ማመቻቸት ተገቢ ይሆናል፡፡

በዚህ ምዕራፍ ሥርም ሕፃናቱ እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን እንዲማሩ በሁለት ክፍሎች ተከፍሎ ቀርቧል፡፡ ሕፃናቱ ገና ወደ ት/ቤት የመጡ ማለትም ቅድመ መደበኛ ትምህርት ያላገኙ ሊሆኑ ስለሚችሉ ለዚህ ቅድሚያ ሁኔታቸዉ ተገቢዉን ግምት በመስጠት ትምህርቱን ማቅረብ ይጠበቃል፡፡

ከምዕራፍ የሚጠበቁ የመማር መስተማር ዉጤቶች

ከዚህ ምዕራፍ ትምህርት በኋላ ተማሪዎች ፣

- እስከ 9 ያሉትን የመቁጠሪያ ቁጥሮች፡ያነባሉ፣ ይፅፋሉ፡፡
- እስከ 9 የሉትን የመቁጠሪያ ቁጥሮች በቅደም ተከተል ይገልፃሉ፡፡
- የ < ፣ = እና > ምልክቶች ተጠቅመዉ እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን ያወዳድራሉ፡፡

1.1 ከ 1 እስከ 5 ያሉ የመቁጠሪያ ቁጥሮችና ቅደም ተከተላቸዉ (10 ክ/ጊዜ)

1.1.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- ብዛታቸዉ ከ 5 የማይበልጡና ልዩ ልዩ የሚቆጠሩ ነገሮችን ወይም ቁሳቁሶችን መግለፅ፡፡
- እስከ 5 ያሉ የመቁጠሪያ ቁጥሮችን በቅደም ተከተላቸዉ መግለፅ፡፡
- የሚቆጠሩ ነገሮችን በመጠቀም እስከ 5 ያሉ ብዜቶችን ማወዳደር፡፡
- የ < ፣ = እና > ምልክቶች ለይተዉ ይገልፃሉ፣ ቁጥሮችንም ለማወዳደር ይጠቀሙባቸዋል፡፡

1.2 ከ6 እስከ 9 ያሉ የመቁጠሪያ ቁጥሮች እና ቅደም ተከተላቸዉ (10 ክ/ጊዜ)

- ከ6 እስከ 9 ያሉትን የመቁጠሪያ ቁጥሮች ማንበብ፡፡
- ከ6 እስከ 9 ያሉትን የመቁጠሪያ ቁጥሮች መፃፍ፡፡
- የአንዱን ቁጥር ተከታይና ቀዳማይ ቁጥሮች ለይተዉ መግለፅ፡፡
- ከ1 እስከ 9 ያሉትን የመቁጠሪያ ቁጥሮች ያወዳድራሉ፣ በቅደም ተከተልም መግለፅ፡፡
- ከ 1 እስከ 9 ያሉትን የመቁጠሪያ ቁጥሮች በቁጥር ጨረር ይገልፃሉ፡፡

ምዕራፍ 2
እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን መደመርና መቀነስ

መግቢያ

የዚህ ምዕራፍ ትምህርት የሚያተኩረዉ ተማሪዎች በምዕራፍ አንድ የተማሩትን እስከ 9 ያሉ የመቁጠሪያ ቁጥሮች ተጠቅመዉ የመደመርና የመቀነስ ስሌቶችን በማስተዋወቅ ላይ ነዉ፡፡ የመደመር ስሌት በቁጥሮች የሚከናወን ነዉ፡፡ ይህም ለምሳሌ ሁለት ቁጥሮችን መደመር የተባሉትን ያህል ብዛትና የጋራ ባህሪይ ያላቸዉን ነገሮች አንድ ላይ በመቀላቀል ብዛታቸዉን ከመግለጽ ጋር የቅርብ ዝምድና አለዉ፡፡ በሌላም በኩል ለምሳሌ የበጎችንና የላሞችን ብዛቶች አንድ ላይ መደመር አንችልም፡፡ ላሞቹንና በጎቹን አንድ ላይ ልንሰበስባቸዉ ወይም ልንቀላቅላቸዉ ግን እንችላለን፡፡ የበጎችና የላሞችን ብዛት ብቻ የሚገልጹ ቁጥሮችን ግን መደመር እንችላለን፡፡ በዚህ ምዕራፍ ትምህርት እስከ 9 ባሉ መቁጠሪያ ቁጥሮች በመጠቀም ከመደመርና መቀነስ ስሌቶች ጋር ይተዋወቃሉ፡፡ ስለዚህም በዚህ ምዕራፍ ትምህርት ተማሪዎች ለመጀመሪያ ጊዜ ከነዚህ ስሌቶች ጋር መለማመድ ስሚጀምሩ ወይም ስለሚተዋወቁ በቂ ጥንቃቄ ባለዉ አካሄድ ትክክለኛዉ ዕዉቀት ማስጨበጥ ይጠበቅብናል፡፡

ከምዕራፉ የመጠበቁ የመማር ማስተማር ዉጤቶች

ከዚህ ምዕራፍ ትምህርት በኋላ ተማሪዎች፡-

- እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን ይደምራሉ፡፡
- እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን ይቀንሳሉ፡፡
- ድምራቸዉ ከ 9 የማይበልጡ 3 ቁጥሮችን ይደምራሉ፡፡

2.1 ድምራቸዉ ከ9 የማይበልጡ የመቁጠሪያ ቁጥሮችን መደመር (9ክ/ጊዜ)

2.1.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- እስከ 5 ያሉ መቁጠሪያ ቁጥሮችን መደመር፡፡
- እስከ 9 ያሉ መቁጠሪያ ቁጥሮችን መደመር፡፡

2.2 **እስከ 9 ያሉ መቁጠሪያ ቁጥሮችን መቀነስ** (9ክ/ጊዜ)

2.2.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- እስከ 9 ያሉ የመቁጠሪያ ቁጥሮችን መቀነስ፡፡
- የመቀነስና የመደመር ዝምድናን መጠቀም፡፡
- ቀላል የመቀነስ የእኩልነት ዐረፍተ ነገርን መመሥረት፡፡

2.**3 ድምራቸዉ ከ9 የማይበልጡ ሶስት መቁጠሪያ ቁጥሮችን መደመር** (4 ክ/ጊዜ)

2.3.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

ድምራቸዉ ከ 9 የማይበልጡ ሶስት ቁጥሮችን መደመር፡፡

ምዕራፍ 3
ከ 0 እስከ 20 ያሉ ሙሉ ቁጥሮች

መግቢያ

ባለፉት ምዕራፎች ተማሪዎች እስከ 9 ካሉ መቁጠሪያ ቁጥሮች ጋር ተዋዉቀዋል፡፡ በእነዚህ ቁጥሮችም መደመርና መቀነስ ተምረዋል፡፡ በዚህ ምዕራፍ ደግሞ እስከ 20 ያሉትን ሙሉ ቁጥሮች እንዲማሩ ቀርቦላቸዋል፡፡ እዚህ ላይ መዘንጋት የሌለበት አንዱ መሠረታዊ ሃሳብ ቁጥርና መቁጠር የተለያዩ መሆናቸዉን ነዉ፡፡ መቁጠር ብዛትን መግለጫ ዘዴ ነዉ ብዛትን ለመግለጽ ደግሞ ቁጥሮችን እንጠቀማለን፡፡ ይህንን ግንዛቤ በመዉሰድ ሕፃናት ቁጥሮችን በሚገባ ለማወቅ እንዲችሉ ነገሮችን በብዛት እንዲጠቀሙ መርዳት ጠቀሚ ነዉ፡፡ ከነገሮች ብዛት ጋር የአንድ ለአንድ ዝምድና ሲሰሩ የቁጥሮችን ስም ማለማመድ ይቻላል፡፡ በዚህ ሂደት ተማሪዎች ቁጥሮችን በሽምደዳ ብቻ ሳይሆን እስከ ትርጉማቸዉ ይገነዘባሉ፡፡

ለምሳሌ ሕጻናት ከቁጥሮች ሁሉ በቅድሚያ የሚገነዘቡት ቁጥር “2” ን ሊሆን ይችላል፡፡ ምክንያቱም በተፈጥሮ ከብዙ ሁለቶችን ከሚገለጹ ነገሮች ጋር ናቸዉ፡፡ 2 እጆች፣ 2 እግሮች፣ 2ዓይኖች ሌሎችም 2 ሁለት ነገሮች አሏቸዉ፡፡ በዚህ ሁኔታ ሌሎችንም ቁጥሮች ከተጨባጩ እዉነታ ጋር እያዛመዱ ሌሎችንም ቁጥሮች እንዲረዱ ማገዝና መምራት ይቻላል፡፡

ከምዕራፉ የሚጠበቁ የመማር ማስተማር ዉጤቶች

ከዚህ ምዕራፍ ትምህርት በኋላ ተማሪዎች

- ስለ ዜሮ በመረዳት ዜሮን በምልክት ይገልፃሉ፡፡
- እስከ 20 ያሉ ሙሉ ቁጥሮችን ያነባሉ፣ ይፅፋሉ፣ በቅደም ተከተል ያስቀምጣሉ፣ ያወዳድራሉ

3.1 ዜሮ ቁጥር/3 ክፍለ ጊዜ

3.1.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- የዜሮን ፅንሰ ሃሳብ በዉይይት ማብራራት፡፡
- የዜሮን ምልክት ማንበ፣ በፃፍ
- ዜሮን (“0”) በመጠቀም ቁጥሮችን በቅደም ተከተል ማስቀመጥ፡፡
- “0” ን በመጠቀም መደመር ፣ መቀነስ

3.2 እስከ 20 ያሉ ሙሉ ቁጥሮችና ቅደም ተከተሎቻቸዉ (6 ክፍለ ጊዜ)

3.2.1 በንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- እስከ 20 ያሉ ሙሉ ቁጥሮችን ወደፊትም ሆነ ወደኋላ መዘርዘር ፡፡
- በ10 እና በ20 መካከል ያሉትን ሙሉ ቁጥሮች እንደ 10 እና ባለ አንድ ሆሄ ቁጥር ድምር በማድረግ መግለጽ፡፡
- እስከ 20 ያሉ ቁጥሮችን ቀደማይና ተከታይ ቁጥሮችን ለይተዉ መግለጽ
- “=”, “<”, እና “>” ምልክቶችን በመጠቀም እስከ 20 ያሉ ሙሉ ቁጥሮችን ማወዳደር፡፡
- 3.3 የቁጥር ቤት ዋጋ ሥርዓት /3 ክፍለ ጊዜ/
- 3.3.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮት
- ከዚህ ንዑስ ርዕስ ትምህርት መጠናቀቅ በኋላ፡-
- ተማሪዎች እስከ 20 ያሉትን ሙሉ ቁጥሮች በቤት ዋጋ ሥርዐት ይገልፃሉ፡፡

ምዕራፍ 4
እስከ 20 ያሉ ሙሉ ቁጥሮችን መደመርና መቀነስ

መግቢያ

መደመርና መቀነስ በቁጥሮች የሚከናወኑ ስሌቶች ናቸዉ፡፡ ሕጻናትን በቀጥታ ወደ እነዚህ ስሌቶች መማር በቀጥታ ይዘን ከመግባታችን በፊት ነገሮችን ወይም ቁሳቁሶችን በመቧደን (በቡድን በቡድን በማድረግ መቁጠር በሚገባ ደጋግመዉ እንዲለማመዱ ማድረግ በጣም ጠቃሚ ነዉ፡፡ ከዚያም በማስከተል በተለያዩ ዘዴዎች ይህንን ግንዛቤያቸዉን በመጠቀም መደመርንና መቀነስን በቀላሉ ማለማመድ ይቻላል፡፡ እዚህ ላይ መዘንጋት የሌለበት አንዱ ጉዳይ መቀነስን ከመደመር ጋር ብቻ አዛምዶን ማስተማር ብቻዉን በቂ ያለመሆኑን ነዉ፡፡ ሁለቱም ስሌቶች ችሎ ሊቀርብ የሚችል ነዉ፡፡

የዚህ ምዕራፍ ትምህርትም ድምራቸዉ ከ20 የማይበልጡ ሙሉ ቁጥሮችን መደመርና እስከ 20 ያሉ ሙሉ ቁጥሮችን መቀነስ ማስተዋወቅና ማለማመድ ላይ ያተኩራል፡፡

ከምዕራፉ የሚጠበቁ የመማር ማስተማር ዉጤቶች

- እስከ 20 ያሉ ሙሉ ቁጥሮችን ይደምራሉ፡፡
- እስከ 20 ያሉ ሙሉ ቁጥሮችን ይቀንሳሉ፡፡ እስከ 20 ያሉ ሙሉ ቁጥሮችን ያካተቱ የመደመርና የመቀነስ የቃላት ፕሮብሎሞችን ይፈታሉ፡፡

4.1 ድምራቸዉ ከ20 የማይበልጡ ሙሉ ቁጥሮችን መደመር (7 ክፍለ ጊዜ)

4.1.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- እስከ 20 ያሉ ሙሉ ቁጥሮችን መደመር፡፡
- እስከ 20 ያሉ ቁጥሮችን በሁለት ተማሪዎች አድርገዉ መግለፅ፡፡
- መደመርን ለአንድ ቁጥር ከሌላዉ ማነስ ወይም መብለጥ ምክንያት አድርገዉ መስጠት መቻል፡፡

4.2 እስከ 20 ያሉ ሙሉ ቁጥሮችን መቀነስ (7 ክፍለ ጊዜ)

4.2.1 ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

- እስከ 20 ያሉ ሙሉ ቁጥሮችን በመጠቀም መቀነስ መቻል፡፡

4.3 የመደመርና የመቀነስ ፕሮብሌሞች(3 ክፍለ ጊዜ)

4.3.1. ከንዑስ ርዕሱ የሚጠበቁ የብቃት መስኮች

ከዚህ ርዕስ ትምህርት በኋላ ተማሪዎች

- እስከ 20 ያሉ ሙሉ ቁጥሮችን ያካተቱ የመደመርና የመቀነስ የቃላት ፕሮብሌሞችን ይፈታሉ፡፡
- ቀላል የቃላት ፕሮብሌሞችን ይመሰርታሉ፡፡