CONSTRUCTIVIST PEDAGOGY AND THE DEVELOPMENT OF MATHEMATICS COMPETENCES AMONG PRE-PRIMARY SCHOOL CHILDREN IN KIRA MUNICIPALITY-WAKISO DISTRICT

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A RESEARCH DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF A DEGREE OF MASTERS OF EDUCATION IN EARLY CHILDHOOD DEVELOPMENT OF KYAMBOGO UNIVERSITY

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DECLARATION

I, **Grace Gloria Kembubi**, declare that this dissertation titled "Constructivist Pedagogy and the Development of Mathematics Competences: A case of selected Pre- Primary Schools in Kira Municipality, Wakiso District" is my original work which has never been submitted to any institution for any award. I am now submitting it to the Graduate School, Early Childhood Department, Kyambogo University, with the approval of my supervisors.

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Supervisors' Declaration

This dissertation titled "Constructivist Pedagogy and the Development of Mathematics Competences: A case study of selected Pre-Schools in Kira Municipality, Wakiso District" has been developed by Grace Gloria Kembubi with our guidance and it is now submitted for examination with our consent as supervisors.

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Dr. Stephen Ndawula

Supervisor

Dedication

I dedicate this work to my friends Baluku Fundi Josiah, Tibesigwa Carol, my brother Kwezi Andrew, my daughters Peace Ahumuza, Carolyn Karungi and Rachael Nyamata.

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I would like to acknowledge the almighty God for granting me the strength and wisdom to carry on with this project. This research would not have been possible without the essential and gracious support of my supervisors, Dr. Ejuu Godfrey and Dr. Stephen Ndawula. I appreciate them for their willingness to motivate and professionally empower me.

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Abbreviations and Acronyms

CCP	Child Centered Pedagogy
CP	Constructivist Pedagogy
CRA	Concrete- Representation- Abstract Model
DAP	Developmentally Appropriate Practice
ECCD	Early Childhood Care and Development
ECCE	Early Childhood Care and Education
ECD	Early Childhood Development
ECDE	Early Childhood Development Education
ECDTIA	Early Childhood Development Training Institutions Association
ECE	Early Childhood Education
ECEC	Early Childhood Education and Care
EFA	Education For All
EGMA	Early Grade Mathematics Assessment
EMIS	Education Management Information System
I.Q	Intelligence Quotient
MoES	Ministry of Education and Sports

NAEP	National Assessment of Educational Progress
NAEYC	National Association for the Education of Young Children
NCDC	National Curriculum Development Centre
NCTM	National Council of Teachers of Mathematics
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study
UCRNN	Uganda Child Rights NGO Network
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO	United Nations Education Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UPE	Universal Primary Education

Abstract

This study on Constructivist Pedagogy and the Development of Mathematics Competences in selected Pre- Primary Schools in Kira Municipality was based on constructivism theory of learning. The purpose of the study was to investigate the development of mathematics competences through constructive pedagogy. The researcher used descriptive cross sectional design and employed both qualitative and quantitative approaches for the study. Primary and Secondary sources were explored as the main sources for data. The sources used in obtaining data were from journals, articles, textbooks, magazines and research publications. The researcher used Simple random sampling, purposive as well as stratified method to select key subjects that participated in the study. The Questionnaires, observation, documentation and interview guides were used as data collection instruments for the study. The researcher used structured questionnaires which were both closed ended and open ended. The researcher went on to analyze data to formulate frequency tables and charts on which data was presented. The researcher sampled 86 teachers and 10 headteachers from 10 Pre-Primary schools. The findings of this study revealed that over 98% of the teachers considered use of counting sticks in teaching mathematics competences. The findings further revealed that 87% of the respondents agreed that CRA model improved on the learners' representation ability. Results also showed that most of the pre-primary schools used physical play to develop mathematics competences (83.3%), followed by creative play (75.9%) and lastly games with rules (27.8%). The study concluded that CRA model enabled learners to develop representation abilities, and ability to construct mathematics concepts. It is recommended that school administrators should invest in the relevant types of mathematics manipulative materials in play and emphasize the CRA model of teaching.

CHAPTER ONE

BACKGROUND OF THE STUDY

1.1 Introduction

The study sought to investigate the relationship between constructivist pedagogy and development of mathematics competences among selected preprimary learners. This chapter presents the background of the study which entails historical, theoretical, conceptual and contextual perspectives. It also presents the statement of the problem, purpose; objectives, research hypothesis, the scope and significance of the study.

1.2 Background of the study

In recent years, early childhood mathematics education has become a widely discussed topic and the importance to provide all children with basic mathematical competencies has become increasingly recognized. Postulating that early mathematics education should be sustainable, compatible with further mathematical learning and consider the individual stage of children's learning (Grüßing 2009), it is necessary to carefully think about how early mathematics education should be organized and designed. Nowadays many materials, concepts and learning programs are offered in different nations (Preiß 2007; Krajewski et al. 2007b; Wittmann and Müller 2009; Kaufmann and Lorenz 2009). They differ considerably and vary from a very narrow perspective of mathematical learning and guided interactions, to a broad understanding of mathematics as science, emphasizing problem solving, creativity, representation, communication and discovery learning.

In USA, over the decades, it has led to the creation of national assessments such as the National Assessment of Educational Progress (NAEP). The NAEP has been influenced by the Trends in International Mathematics and Science Study (TIMSS) as well as by input from policy makers, practitioners, and other interested parties such as the National Council of Teachers of Mathematics (NTCM), and the National Research Council.

Currently, the teaching and learning of science, technology, engineering, and mathematics (STEM) education has become a national priority. This focus has, in part, been driven by concerns over international competitiveness. The focus is also fueled by data showing that young people are not graduating with the skills needed to succeed in a rapidly-evolving, technologically-driven workforce (Murphy, 2018).

In the last two decades, there have been numerous initiatives to reform pedagogical practices in sub-Saharan Africa as a means to improve education quality. In the majority of African classrooms, pedagogical practices are described as authoritarian, teacher-dominated and lecture-driven. Evidence suggests that this type of teaching merely fosters rote learning and does not support development of conceptual learning, critical thinking and problem-solving skills (Dembele, 2005). The reform efforts often emphasised a move away from teacher-centred instruction to constructivist pedagogy (CP) which is also known child-centred pedagogy (CCP). The international development agencies have been influential in the diffusion of CP within the continent as many have advised CP as a prescription through educational projects and consultancies that were funded by them (Tabulawa, 2003).

By the late twentieth century, CCP has been diffused across sub-Saharan Africa. As Chisholm and Leyendecker (2008) note ‘It is one of the most pervasive educational ideas in the contemporary sub-Saharan Africa and elsewhere'. Currently, curricular reforms in many African countries emphasise CCP as the official pedagogy in schools. Examples include Botswana, South Africa, Namibia, Tanzania, Ethiopia, and Kenya. Some authors emphasise the traditional mechanisms of policy borrowing and policy learning, and argue that CCP has become popular in sub-Saharan Africa as new pedagogical ideas spilled over from the USA and Europe into the continent. This has particularly resulted from development import by sub-Saharan African countries, development export on the part of the western world, and increased international communications (Chisholm and Leyendecker 2008). Child Centered Pedagogy has long been established in western education systems and considered a western 'best practice' in many countries (Carney 2008). It enjoys an almost hegemonic position with its 'justified', 'admirable' and 'inspiring' educational ideas. According to Nykiel-Herbert (2004), CCP has become increasingly preferred in developing countries which are making the transition to democracy. The pedagogy is highly appealing in such countries because it carries the promise of intellectual liberation from traditional approaches that are considered oppressive.

Although substantial resources have been invested in pedagogical renewal, recent studies show that teaching and learning in African classrooms continues to be characterised by traditional, teacher-dominated instruction (Munyaradzi, 2013). Research also shows that some teachers in primary schools have undertaken substantial changes and revised their practices, contributing to improved performance in mathematics in their schools (Hesson and Shad, 2007). Questions about the effectiveness of constructive methods on pre-primary pupils learning have consistently raised considerable interest in the thematic field of educational research. In addition, it is not clear whether teachers in early child hood development education (ECDE) schools utilise constructive pedagogy approaches in teaching and learning of mathematics especially in Uganda, which was the focus of this study.

In East Africa, Early Grade Mathematics Assessment (EGMA) identified gaps in the mathematics education that children are receiving at an early age (Gellar, 2014). The Government of Uganda through the National Curriculum Development Centre (NCDC) developed the learning framework to be used to teach children in all preprimary schools in Uganda, instead of a syllabus as used in the primary schools. The learning framework is theme based and is centered on five learning areas. The teaching of mathematics is catered for in Learning Area 4, which is developing and using mathematical concepts in day to day experiences. However, the development of mathematics is still registering high failure rates at different learning levels (EMIS 2014).

In Uganda, children at early stages tend to struggle in mathematics due to legacies of objectivist pedagogies, thus affecting early mathematics competences. After examining the motivations of development agencies to enhance mathematics competences through introduction of constructivism into developing countries, scholars explored the reasons why constructivist pedagogies have not taken hold in Ugandan classrooms in previous years. A number of studies had described the primary school curriculum in Uganda as too theoretical, pays scant attention to the development of competencies and skills, generally out of date, overloaded and not learner-centred (Najjumba and Marshall, 2013; Ezati, 2016). At pre-primary education level in Uganda however, both access and quality are low with enrolment currently standing at 9.5% implying a 90.5% gap (ESSAPR) 2013/14).

According to the MoES (2007), ECD policy to guide stakeholders or direct government control over pre-primary education had led to undesirable trends with regard to the content and quality of the curriculum, teaching methods, facilities, entry age to primary one and quality of teachers and their training programs. The training of nursery teachers/caregivers was not streamlined, most of the training institutions were private, with each institution offering training following its own curriculum, different entry requirements for trainees; and, certificates offered were not accredited to any recognized body (UCRNN, 2010). International development organizations are therefore increasingly promoting constructivist pedagogies in developing countries so as to improve on mathematics competences at early learning (Craig, 2009).

This study was built on constructivism theory that was officially recognized in the early 1990s. The idea of constructivism is based on the fact that the human brain does not directly reflect the external world, but constructs its experience and life in cognitive and emotional processes in the social context as subjective ideas and concepts (Bognar, Gajger, and Civic, 2015). Constructivist ideas are also found in several works including ideas of theorists Dewey, Piaget, Vygotsky, Candy, Driver, Merizow, Boud among others. According to Hussain and Sultan (2010), it should be noted that mathematics education is more influenced by Piaget, Vygotsky, and von Glasersfeld ideas, therefore for the purpose of this study, the researcher based on Piaget cognitive theory put forward in 1977 and Vygotsky social theory put forward in 1978. Piaget's works had a great influence on mathematics education. Piaget's ideas were considered a new field in mathematics education, which encouraged the development of cognitive knowledge.

According to the Piaget's theory of cognitive development, it is not possible to provide information which will be immediately understood and used, but the students themselves build their knowledge as a result of assimilation and accommodation processes (Piaget, 1977). Piaget states that all knowledge is constructed and the instrument of construction includes cognitive structures that themselves are products of continued construction. That characterizes constructivism as cognitive position. Piaget theories describe the structures of mind, focusing on in the human mind, how a person assimilates information and adjusts or does not adapt it to the one he knows.

The Russian psychologist Vygotsky emphasized the importance of the social environment in cognitive development as well as culture and people as the most important factors in the development of an individual. He proved that an individual cannot develop without interacting with the environment (Vygotsky, 1978). Constructive processes are particularly strong in group conditions, where each individual has a sense of the complex social interactions in which he is included. This therefore looks at a classroom that allows pupils interact with their teachers while using manipulatives to develop mathematic competences. Vygotsky considered that knowledge starts at the social level, and only then it becomes individual knowledge (Vygotsky, 1978). These theories explained how pre-primary school children and teachers apply constructivist pedagogy to develop the mathematics competences.

In this study, constructivist pedagogy was the independent variable while mathematics competence was the dependent variable. There is a growing consensus in policy and research that early mathematics competence is important and bears relevance for children's development in the short and long term. Young children can possess deep and rich mathematical competencies (English and Mulligan 2013; Newton and Alexander 2013), and several studies show that early mathematical competencies have positive effects on later school performance (Duncan et al. 2007; Perry and Dockett 2008; Ginsburg 2009).

Mathematics competencies in kindergarten develops logical ability to number recognition, number sequence, counting, ordinality, relative size, addition and subtraction among early learners which are the strongest predictors for later school achievement (Duncan et al. 2007). Children with low mathematical competencies in kindergarten are most likely to experience difficulties with mathematics at high school levels (Dornheim 2008). A strong foundation in mathematics during the early grades is the key to future success in mathematics, which is instrumental in the development of workplace skills and knowledge (Steen, 2001; U.S. Department of Education, 2008).

Recent meta-analyses also suggest that early mathematics competence predict later reading skills just as much as early reading skills (Duncan et al., 2007; Romano et al., 2010). Similarly, Oliver (2000) development of mathematics competence usually means encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing.

Quantity number competencies predict later mathematical competencies beyond number words whilst phonological awareness does not (Krajewski and Schneider 2009). Children's mathematical competences differ considerably in kindergarten, which is also due to differences in the home learning environment (Anders et al. 2012; Sonnenschein and Galindo 2015). In order to enhance opportunities for all children, regardless of their family background, kindergarten needs to foster mathematics intentionally (Grüssing and Peter-Koop 2008) and children need to be provided with learning opportunities which meet their diverse educational needs (Gasteiger 2015), as with other subject areas, the quality of teaching is crucial but also highly variable (McCray and Chen 2012).

Githua and Mwangi (2003), as stated in Thin (2015) noted Mathematics allows people to perform complex calculations using a set formula or mathematical procedure. The development of mathematics proficiency begins in the preschool years, and individuals become increasingly mathematically proficient over their years in educational settings. Early mathematical concepts lay the foundation for later learning by providing students with underlying mathematical structures which are built upon over time.

On the other hand, Constructivist pedagogy provides a very important means of enhancing learning and practices teachers' ability in developing mathematical competences. Constructivist pedagogy assumes that the more effective it becomes, the more repeated it is doing. It consists of various forms and activities it involves the use of different approaches such as Concrete-Representational-Abstract (CRA model), play and the use of different kinds of manipulatives (Hussain and Sultan, 2010). It is based on the active involvement of pupils and their interaction with the creation of new knowledge. Critical thinking, problem-solving approach and analytical skills are the most important skills that are developed in the process of mathematics education and are also the cornerstones of sustainability.

Manipulatives are concrete learning materials that allow students to comprehend abstract concepts through concretizing them (Boggan et al, 2010; Cope, 2015; Laski et al., 2015; White, 2012), thus help them to establish a relation between the manipulatives and abstract mathematical concepts by offering concrete experiences (Holmes, 2013) and eventually, provide long-term permanence of mathematical skills (Cass et al, 2003). Manipulatives enable students to integrate their knowledge and associate them with their thoughts in order to understand mathematical concepts thoroughly (Boggan et al, 2010); they contribute to students' communication with their own mathematical thinking and to bringing their mathematical ideas to a higher cognitive level (Ojose and Sexton, 2009). They also evoke amusement in the teaching process by providing active participation of both students and teachers (Boggan, Harper, and Whitmire, 2010; Ojose and Sexton, 2009) and in this way, lead to permanent learning through creating equality of opportunity among students (Şahin, 2013).

Tunç, Durmuş and Akkaya (2011), stated that manipulatives are instruction materials which facilitate teaching and learning (Tunç, Durmuş, and Akkaya, 2011), and make positive contributions to conceptualization and interpretation process. They include attribute blocks, geometric shapes of different colors and sizes that may be used in classification or patterning tasks; plastic counting cubes for solving simple addition and subtraction equations.

Current reform thinking in mathematics education indicates that the use of manipulatives in mathematics teaching increases students' conceptual knowledge and improve their attitudes toward mathematics learning (Reimer and Moyer, 2005). Manipulatives significantly help children with picturisation and imagination, resulting in enhanced comprehension from a very early age of mathematics and numbers (Marchis, 2012; Nurhasanah et al., 2017).

Concrete Representational Abstract (CRA) is a three step instructional approach that has been found to be highly effective in teaching math concepts at early learning. The first step is called the concrete stage. It is known as the "doing" stage and involves physically manipulating objects to solve a math problem. The representational (semi-concrete) stage is the next step. It is known as the "seeing" stage and involves using images to represent objects to solve a math problem. The final step in this approach is called the abstract stage. It is known as the "symbolic" stage and involves using only numbers and symbols to solve a math problem. CRA is a gradual systematic approach. Each stage builds on to the previous stage and therefore must be taught in sequence. This approach is most commonly used in elementary grades, but can be found in some middle and high school classrooms (Terry Anstrom, 2012).

Constructivist pedagogy to early mathematics should not only be developmentally adequate and effective, but also compatible with the kindergarten pedagogy. Since kindergarten children are highly motivated to learn in an informal, instructional way, play can be regarded as a powerful vehicle for learning (Hauser 2005). Play can be defined as activities that ‘are fun, voluntary, flexible, involve active engagement, have no extrinsic goals, involve active engagement of the child, and often have an element of make-believe’ (Weisberg, Hirsh-Pasek, and Golinkoff, 2013).

Given the importance of play as a learning process for young children, it is essential that good mathematics pedagogy recognises this fact, honours it and harnesses its power. Sarama and Clements (2009) identify three types of play in which children engage with mathematics: sensorimotor play, symbolic or pretend play, and games with rules. Aistear (NCCA, 2009a) promotes a range of different types of play, i.e., ‘creative’, ‘games with rules’, ‘language’, ‘physical’ and ‘pretend’. Although not outlined specifically in Aistear, all of the above types of play contribute in their own way to children’s mathematical learning and can offer valuable opportunities for playful mathematical experiences (Ginsburg et al., 2006; Perry and Dockett, 2008).

In Uganda, some parents’ views and thinking about mathematics competences in early education show that the learners are limited to counting and not to any further mathematical abstract numerical notation such as written numerals. This has contributed to low competence attainment as learners progress to primary level. Fundamentally, in Uganda’s Pre-primary schools and in particularly Kira Municipality, by the time learners complete their final year of pre-primary school, they are expected to be able to apply mathematical concepts in their day- to-day experiences. Children at this stage have developed ‘number sense’ and ‘basic mathematics operation’ competences so as to be able to recognize or create number patterns and represent or interpret information in pictorial form (NCDC, 2005).

Wakiso is one of the 134 districts in Uganda where learners pass highly during Primary Leaving Examinations (PLE) but mathematics being registered as the worst performed subject. In this study, Kira Municipality was selected because it has learners with low mathematics competence levels in comparison with the national standards. This is evident in the ten selected Schools of Kira Municipality where the failure to achieve mathematics competence was at 33%. This was as a result of poor mathematics background at early childhood in pre-primary schools which is alarming for an urban setting (Ministry of Education 2017). In the ESSAPR (2013/14) it was stated that the quality of pre-primary education is a multifaceted issue with dimensions that include among others; safety and adequacy of the physical environment, teacher pedagogical and content knowledge, teacher education and training, and content of early learning programs.

Although it was noted that 60% of the Early Childhood Development (ECD) centres in Kira Municipality had a learning framework at the school, the caregivers were struggling to use it. Furthermore training institutions encouraged trainees to buy personal copies, the only sole reliable reference to guide teaching. Nevertheless, most of the centres possessed it for the sake of fulfilling Ministry of Education and Sports (MoES) requirements, in case of monitoring checks, but do not use them for teaching and learning. This was due to the need to fulfill the status of implementation of the ECD Policy in Uganda primary schools, however they have continued to use their own curricula often developed without making reference to the ECD learning framework, which was assumed to be substandard as a result of failure to understand it (Ejuu, 2012). This has contributed to continued failure to develop early mathematics competences which prompted the author to carry out the study on the relationship between constructivist pedagogy and development of mathematics competences.

1.3 Statement of the Problem

If constructivist pedagogy is used to teach mathematical concepts as implied in the 2017 ECD policy children can achieve the expected competences because they are actively involved in the implementation of constructivist approach of learning. The development of mathematics proficiency begins in the preschool years, and individuals become increasingly mathematically proficient over their years in educational settings.

However, in Kira Municipality, learners joining primary schools from Nursery schools have challenges in early mathematics competence for example ability to think deductively, ability to abstract, generalise, classify, ability to think, analyse and criticize ideas learnt UMEA Annual Report, (2018). Several studies have shown that there has been a decline in mathematics performance as a result of learning that does not involve constructive pedagogy. In Uganda, there was a drop in performance of mathematics from 32 percent to 26 percent between 2011 and 2013 (UNICEF, 2016). It was observed that quite a number of pre-primary schools still depend on such approaches where it is termed as "mechanistic" approach to teaching (Ejuu, 2012). Despite government's effort to promote constructivist pedagogy in early learning these challenges still persist and it's against this back drop that the researcher sought to investigate the use of constructive pedagogy in developing mathematics competences among pre-primary school children in Kira Municipality Wakiso District.

1.4 Purpose of the Study

To investigate the relationship between constructivist pedagogy and the development of mathematics competences among pre-primary school learners in Kira Municipality-Wakiso District.

1.5 Objectives of the Study

1. To explore the mathematics manipulative materials used in the development of mathematics competences among the selected pre-primary learners in Kira Municipality-Wakiso District.
2. To examine the use of Concrete–Representational-Abstract (CRA model) in developing mathematics competences among selected pre-primary learners in Kira Municipality-Wakiso District.
3. To assess the use of play in developing mathematics competences among selected pre-primary learners in Kira Municipality-Wakiso District.

1.6 Research Hypothesis

1. There is a significant relationship between the use of manipulative materials and development mathematics competences among the selected pre-primary learners.
2. There is a significant relationship between the use Concrete-Representational-Abstract (CRA) and development of mathematics competences among selected pre-primary learners.
3. There is a significant relationship between the use of play and development of the mathematics competences among the selected pre-primary learners.

1.7 Significance of the Study

The study may benefit care givers of pre-primary schools, the head teachers, school proprietors, curriculum developers, education officials and future research scholars. The child caregivers, head teachers and school proprietors may gain knowledge regarding acquisition of appropriate mathematics manipulatives; approaches to develop mathematics competences through constructivist's pedagogy. As a result Learners' participation and mathematics conceptualization may be improved.

Curriculum developers, education officials and early childhood educators may gain insight on the need to emphasis mathematics competences and constructivist pedagogy. This research may also reveal topics and gaps for further scholars as a stepping stone towards other insightful studies along the same theme.

1.8 Limitation and delimitation

Limitation: This study was carried out in an urban area and therefore its findings may not be applied to the rural area. Findings of the study should not be unilaterally generalized for the country due to geographical, social, political and economic differences.

Delimitation: All head teachers of the sampled pre-primary schools were included as respondents in the research study, which might made it hard and tiresome to synchronize the researcher's plans with the plans of respondents who were most of the time busy doing their work. Some of the participant had vague ideas about the subject making it hard to obtain information.

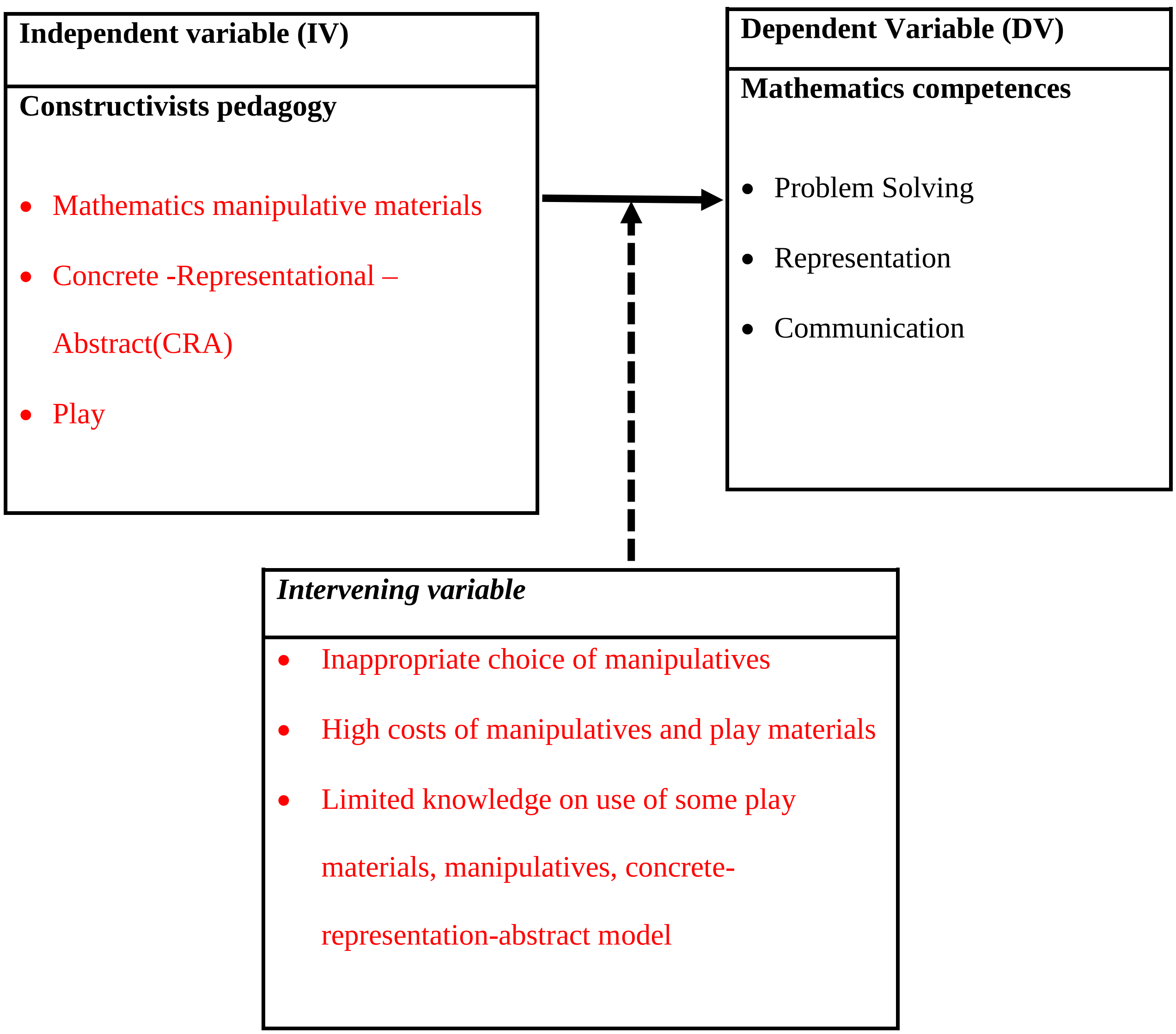
1.9 Theoretical framework

This research was framed within the constructivism theory. Cognitive constructivism emanates from the work of Jean Piaget. Piaget saw the child as an explorer or scientist who investigates the world around him to construct his own understandings and to structure his world intellectually through experience (Edwards, 2005; Palmer, 2005; Windschitl, 2002). Piaget denoted three types of experience in relation to knowledge construction: physical, logical-mathematical and social experience. Physical experience is derived from acting on objects and drawing knowledge directly from the object themselves (Piaget, 1964). Logical-mathematical experience draws knowledge from the actions effected on the objects not from the objects themselves (Piaget, 1964). Piaget also described a third type of experience, social, in which knowledge is derived from experiences or interactions with adults and peers (Palmer, 2005; Piaget, 1964; Wadsworth, 2004).

This theory has been used to "articulate a view of early childhood education that provided learning experiences to young children that were considered suitable to their ages and levels of development, while simultaneously enabling them to 'construct' their own learning. According to Piaget children need to actively explore their learning environments in order to build their own understandings of the world and its various phenomena" (Edwards, 2005). The role of the teacher is therefore to provide experiences which promote learning for children (Palmer, 2005).

1.10 Conceptual Framework

Figure 1.1: Conceptual Framework



Source: (Kumar, 2014)

Figure 1.1 shows the interaction between the two variables that were involved in the study that is constructivist pedagogy which is the independent variable and development of mathematics competences as the dependent variable. The pre-primary teachers presupposes that when constructivist pedagogy is implemented in early mathematics learning through mathematics manipulatives, concrete-representation-abstract model and play then the children will be able to develop mathematics competences inform of problem solving, representation, and communication of mathematics ideas.

The teachers however believe that in the process of promoting constructivist pedagogy through mathematics manipulatives, concrete-representation-abstract model and play, the process is always disrupted by the intervening variables such as inappropriate choice of manipulative and play materials, high cost of the manipulative and play materials, limited knowledge on the use play, manipulative materials and concrete-representation-abstract model.

1.11 Scope of the study

This study scope covered the geographical, content and time aspects.

1.11.1 Geographical Scope

The study was conducted in Kira Municipality. The Municipality is in Wakiso District, located in the central region of Uganda.

The selection of school was based on a semi-urban where there expected high numbers of pre-primary learners and improved levels of early child hood education and facilitation.

1.11.2 Content Scope

The study was centered on the constructivists' pedagogy and development of mathematics competences in pre-primary schools in Kira Municipality. It explored the mathematics manipulative materials, Concrete-Representation-Abstract use and use of play in the development of mathematics competences.

1.11.3 Time scope

The time scope considered the period from 2016-2019 because this was the time when the Early Childhood learning framework was rolled out. This time frame provided room to understand and obtain the appropriate information on whether teachers in preprimary schools are using constructivist pedagogy to develop mathematics competences among their learners.

1.12 Operational definition of terms

Constructivism: an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner'

Constructivist pedagogy: It is based on the belief that learning occurs as learners actively get involved in the process of meaning and knowledge construction.

Manipulative: concrete models that incorporate mathematics concepts, appeal to several senses and can be touched and moved around by students

Mathematics communication: Refers to a developing collection of resources for engaging learners in writing and speaking about mathematics.

Mathematics Competences: It is the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations.

Models: Models include various real objects that are modeled from clay or papier-mâché or cutouts which form three dimensional real objects.

Pedagogy: it refers to interactions between teachers, learners, learning environment and the learning tasks.

Pre-Primary: It is a preparatory stage to Primary School for formal learning 3-6 years old children.

Problem solving skills: Refers to ability to solve problems in an effective and timely manner without any impediments.

Representation skills: Refers to a wide variety of ways to capture an abstract mathematical concept or relationship.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter critically reviews different literatures on Constructivist Pedagogy and the development of mathematics competences. The literature was reviewed in three categories; the first category is a review of manipulatives materials used in development of mathematics competences in pre-primary schools, the second was a review of Concrete-Representational-Abstract and development of mathematics competences, and the third section was a review of related literature to play and development of mathematics competences.

2.2 Mathematics Manipulatives and Developing Mathematics Competences

Manipulatives are defined as concrete real objects (things you can touch and move around) that aid in classification, patterning, counting, equations, fractions, multiplication, and other math tasks. Weiss (2006) defines manipulative as concrete representations of the real objects which can be experienced by the senses. Hynes (2000) also defines manipulative as "concrete models that incorporate mathematics concepts, appeal to several senses and can be touched and moved around by students.

Since ancient times, people from different civilizations have used physical real objects to help them solve the ancient civilization of Southwest Asia used counting boards. Froebel introduced first kindergarten in Germany in 1837, designed and used geometrical blocks and pattern activity blocks among other educational play materials to teach mathematics. His materials were known as" Froebel gifts" as cited in (Margret, 2014).

Furner and Worrell (2017), state that the use of manipulatives in teaching mathematics has a long tradition and a solid research history. They have become a mainstay of mathematical instruction in America as well as internationally. They include attribute blocks, geometric shapes, base ten blocks, unifix cubes, fraction bars, and plastic counting cubes.

Manipulatives can come in a variety of forms and they are often defined as "physical real objects that are used as teaching tools to engage students in the hands-on learning of mathematics" ("Using manipulatives," 2009). George Cuisenaire, a Belgian educator, is famed for his development of the Cuisenaire Rods used today to help teach fraction concepts along with other math ideas; these were developed in the 1950's. Later on, many other math didactics came out of use ideas and led to the Cuisenaire Math Manipulative Company (Furner, 2017).

Models include various real objects that are modeled from clay or papier-mâché or cutouts which form three dimensional real objects. Manipulatives can be used in teaching a wide variety of topics in mathematics, including the objectives from the five NCTM standards: problem solving, communicating, reasoning, connections, and estimation.

The materials should "foster children's concepts of numbers and operations, patterns, geometry, measurement, data analysis, problem solving, reasoning, connections, and representations" (Seefeldt and Wasik, 2006, p.93). Teachers used counters, place-value mats, base-ten blocks, and fraction strips while teaching from the numbers and operations standard. The counters could be used to teach one-on-one correspondence, ordinal numbers, and basic addition and subtraction. The fraction strips could be used to add and subtract fractions or to show equivalent fractions. Pattern blocks, attribute blocks and scales could be used to assist students in the learning basic algebra. Student could use geoboards when trying to identify simple geometric shapes.

Physical manipulatives range from low-cost, simple, everyday items, such as buttons, paper clips, tooth picks, dominoes, money, string, playing cards, rulers, number cubes, graph paper, empty egg cartons, measuring cups, and film canisters to more complex and discipline-specific items, such as calculators, two-color counters, thermometers, decimal tiles, pattern blocks, Cuisenaire rods, geo-boards, tangrams, algebra tiles, and pantomimes (Cope, 2015).

A case study by Moyer (2001) suggests that Indonesian teachers usually use manipulatives just if they have extra time. Moreover, the presence of manipulatives is needed in solid geometry learning. The first Hiele stage of students' mental development in geometry also explains that students' visualization to recognize geometrical objects or concepts is based on prototype sample (Marchis, 2012; Nurhasanah et al., 2017). The objects of mathematics are abstract, while the elementary students, in general, are still at the stage of concrete operational thinking (Ojose, 2008). Theories of learning by Piaget, Brunner, and Ausubel provide reinforcement to the importance of presenting concrete objects in mathematics learning such that the learning becomes meaningful, and therefore, the students could easily understand the concepts and are not easily forgotten (Furner and Worrell, 2017; Cockett and Kilgour, 2015; Larbi and Mavis, 2016).

This learning approach develops the students' skills to observe, to ask, to collect information, to associate in order to find a concept and to communicate in an integrated learning activity (MOEC, 2016). Various manipulatives as the innovation in mathematics learning have been developed to facilitate the students to find or to understand the mathematical concepts. They are produced by small industries that have been experienced in producing teaching aids in collaboration with teachers. Thus, the manipulatives quality can be maintained related to the mathematical concepts.

According to MOEC (2016), the manipulatives are designed to support the implementation of the scientific approach. The manipulatives prepared for this research are various models of planar figure: triangle, kinds of triangle, quadrilateral, kinds of quadrilateral, pentagon, hexagon, and circle. There are also various models of solid figures such as cuboid, cube, triangular prism, pentagonal prism, hexagonal prism, cylinder, quadrilateral pyramid, triangular pyramid, pentagonal pyramid, hexagonal pyramid, and cone which are used to find the concepts and properties of the solid figures. Besides, there are also manipulatives of solid figures' net. The manipulatives for the classical purpose are made following the standard size, and for solid figure manipulatives, the area of the same size are presented with the same color to help the students grasp the concept and properties of the figures.

Toy blocks may stimulate creative, and divergent problem-solving, psychologists recognize two major types of problems. Convergent problems have only one correct solution. Divergent problems can be solved in multiple ways. Because kids can put together blocks in a variety of ways, block play is divergent play. And divergent play with blocks may prepare kids to think creatively and better solve divergent problems. In one experiment, researchers presented preschoolers with two types of play materials (Pepler and Ross, 1981). Some kids got materials for convergent play (puzzle pieces). Other kids were given materials for divergent play (chunky, block-like foam shapes). Kids were given time to play and then were tested on their ability to solve problems. The kids who played with blocks performed better on divergent problems. They also showed more creativity in their attempts to solve the problems (Pepler and Ross 1981).

Cooperative construction play helps kids improve social skills, research suggests that kids become friendlier and more socially-savvy when they work on cooperative construction projects. For example, in studies of children with autism, kids who attended play group sessions with toy blocks made greater social improvements than did kids who were coached in the social use of language (Owens et al 2008; Legoff and Sherman 2006). And research on normally-developing kids suggests that kids who work on cooperative projects form higher-quality friendships (Roseth et al 2009).

Kids who are skilled with toy blocks tend to become better mathematicians. Block play has been linked with math skills, too. In one study, the complexity of a child's LEGO play at the age of 4 years had long-term predictive power: More complex play during the preschool years was correlated with higher mathematics achievement in high school, even after controlling for a child's IQ (Wolfgang et al 2001; 2003). Other research has revealed links between a child's ability to recreate specific structures and his or her current mathematical skills (Verdine et al 2013; Oostermejier et al 2014; Richardson et al 2014). And a study in the Netherlands found that 6th grade students who spent more free time in construction play performed better on a test of mathematics word problems (Oostermejier et al 2014).

Anderson, J., Reder, L., and Simon, H. (2000), many different kinds of manipulatives are commercially available, and it is also possible to make them using common objects, such as craft sticks, beans, or buttons. In using manipulatives to teach basic operations involving whole numbers, it is important to use objects that are uniform and that accurately represent base-ten relationships (a “ten” should be ten times as big as a “one,” rather than using only color to show tens vs. ones). A mat for organizing manipulatives and for children to work on is also essential. When children begin learning two-digit and three-digit numbers, the mat is organized from right to left in columns of ones, tens, and hundreds, to reflect the way that numerals are written.

Ginsburg et al, (2008) found out that providing preschool children with materials that inspire mathematical thinking, such as blocks, shapes, and puzzles, can facilitate the development of foundational skills such as patterning, making comparisons, and early numeracy. Recognizing and capitalizing on children's spontaneous math-related discoveries by asking questions that require children to reflect and respond, by providing vocabulary and representational support, and by demonstrating extension activities that elaborate on and further support mathematical ideas.

Ginsburg et al (2008), Mathematics education for young children: What it is and how to promote. Not all authorities are equally enthusiastic about the use of concrete manipulatives, but there is widespread agreement about the importance of developing conceptual understanding in math. For example, an understanding of basic number concepts, such as being able accurately to count objects, should precede learning written numerals; an understanding of the meaning of multiplication should precede memorizing multiplication tables. Focused assessments should distinguish whether children are struggling with concepts or with other math skills, such as automatic recall of facts. Conceptual understanding can be developed through the use of visual or pictorial representations as well as through concrete manipulatives. Computer-based "virtual" manipulatives are also increasingly available.

A virtual manipulative is defined as "an interactive, Web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge" (Moyer, et al., 2002). They have also been defined as "computer based renditions of common mathematics manipulatives and tools" (Dorward, 2002). Virtual manipulatives are often dynamic visual/pictorial replicas of physical manipulatives (such as pattern blocks, base-10 blocks, geometric solids, tangrams, or geoboards). They are placed on the Internet as *applets,* or smaller stand-alone versions of application programs. Users move the computer mouse to manipulate these dynamic, visual objects. The ability to manipulate virtual manipulatives makes them particularly useful in teaching mathematics interactively.

Virtual manipulatives can be thought of as *cognitive technological tools* (Zbiek, Heid, Blume, and Dick, 2007). Their characteristics as a cognitive tool are evident in the capability that allows users to act on the virtual manipulatives as representations of objects, with the consequences of the user's actions resulting in visual on-screen feedback from the virtual tool. Although virtual manipulatives have some similarities with their physical manipulative counterparts, as cognitive tools, virtual manipulatives have unique characteristics that go beyond the capabilities of physical manipulatives. Their potential is thus increased for mathematically meaningful actions by users and influences the user's learning.

For example, some virtual manipulatives include links among enactive, iconic and symbolic notations, thereby, supporting learners in making connections among these forms of representation. Other virtual manipulatives have the capability to be altered, including changing the shape of the onscreen object or marking the object with mathematical notations. In addition, virtual manipulatives are readily available with unlimited access to many copies of an electronic object through the click of the mouse (Moyer, Bolyard, and Spikell, 2001; Moyer, Niezgoda, and Stanley, 2005).

Virtual manipulatives may be thought of as a unique externalized representational form. Because a representation is thought of as a configuration of signs, characters, icons, or objects that represents something else (Goldin, 2003), virtual manipulatives may be considered a unique form of representation or a combination of several representations. Students' capacity to translate among multiple representational systems influences their abilities to model and understand mathematical constructs (Goldin and Shteingold, 2001). Virtual manipulatives are unique because they provide a visual image like a pictorial model, they can be moved and manipulated like a physical model, and unlike physical models, they feature linked verbal and symbolic notations. The power of virtual manipulatives is in combining several representations in ways that support the learner in connecting multiple aspects of mathematical concepts and ideas.

A study of third graders using several virtual manipulative fraction applets during a 2-week unit on fractions indicated a statistically significant improvement in students' conceptual knowledge and a significant relationship between students' scores on the posttests of conceptual knowledge and procedural knowledge (Reimer and Moyer, 2005). During interviews, students reported that the virtual manipulatives: helped them learn more about fractions, provided immediate and specific feedback, were easier and faster to use than paper-pencil methods, and enhanced their enjoyment while learning mathematics. Further, Suh's (2005) dissertation results in two third-grade classrooms showed a statistically significant difference in student achievement during a unit on fraction addition (favoring virtual manipulatives over physical manipulatives), but not during a unit on balancing algebraic equations. This research highlighted how different representations (i.e., physical versus virtual manipulatives) and even different individual applets (virtual algebra balance versus virtual fraction addition) can each have their own unique characteristics and affordances that promote different kinds of learning for different mathematical purposes.

In Uganda, generally early childhood classes are expected to have corners like; shop corner, nature garden, nature corner and models They can also include potted plants in the class, small school garden plots or mini botanical gardens where different kinds of plants are planted and labeled (MoES, 2011). *Realia* are real objects that can be live real objects or preserved specimens of real objects. The real objects include birds, animals and insects that can be kept in cages, project houses, aquarium or small class corners by the children (Heddens, 2017).

Finally, although the different literature reviewed show different mathematics manipulative materials that are used to develop mathematics competences, they do not clearly indicate the specific competence that the child develops after interacting with the manipulative materials. Further the literature shows that there is limited information about the manipulative materials used in African classrooms and how they enable the learners to develop mathematics competences and most especially in the Ugandan classrooms. It is therefore against such a backdrop that the researcher seeks to investigate relationship between mathematics manipulative materials and mathematics competences in Kira Municipality-Wakiso District.

2.3 Concrete–Representational-Abstract (CRA) Model and Development Mathematics Competences

Concrete Representational Abstract (CRA) is a three step instructional approach that has been found to be highly effective in teaching math concepts. The first step is called the concrete stage. It is known as the “doing” stage and involves physically manipulating objects to solve a math problem. The representational (semi-concrete) stage is the next step. It is known as the “seeing” stage and involves using images to represent objects to solve a math problem. The final step in this approach is called the abstract stage. It is known as the “symbolic” stage and involves using only numbers and symbols to solve a math problem. CRA is a gradual systematic approach. Each stage builds on to the previous stage and therefore must be taught in sequence (Witzel, Riccomini and Schneider, 2008).

During the concrete stage of instruction, three-dimensional objects are employed so students can use the manipulatives to assist while they are learning the new concept (Miller and Kaffar, 2011). The use of manipulatives increases the number of sensory inputs a student uses while learning the new concept, which improves the chances for a student to remember the procedural steps, needed to solve the problem (Witzel, 2005). In the representational stage of instruction, students are taught to use two-dimensional drawings (instead of the manipulatives from the concrete stage) to represent the same concepts. The manipulations in the concrete and representational stages allow students to rationalize the conceptual mathematical procedures into logical steps and understandable definitions (Witzel, Riccomini, and Schneider, 2008). When students encounter a difficult mathematical problem, they are able to construct pictorial representations to assist in finding the solution (Witzel, 2005). In the abstract stage, students are taught how to translate the two-dimensional drawings into the conventional mathematics notation to solve the problem (Miller and Kaffar, 2011).

It is important to remember CRA is an interconnected instructional sequence where each lesson relates to the previous lesson(s). These explicit connections between lessons and stages are crucial in order for students to learn the targeted skill as well as comprehend the associated concepts (Witzel, Riccomini and Schneider, 2008). Students with Learning Disabilities (LDs) generally need explicit guidance and support when learning the new concepts and skills across settings (Witzel, Riccomini and Schneider, 2008). Sealander, Johnson, Lockwood and Medina (2012) suggest each stage should consist of three lessons. Miller, Mercer and Dillon (1992) note that each lesson should follow the same format, at the beginning of a lesson, students should be given a graphic organizer. The teacher should demonstrate the new skill and have the students model the process. Through guided practice students try some problems and receive feedback on the process. Finally students independently practice the new skill(s).

The thinking ability of elementary school students still use the ability to think concretely so that abstract mathematical concepts can be understood naturally. Therefore this needed an approach that can help their thought stage from concrete to abstract. Mathematics lessons are taught gradually starting from simple concepts to a more difficult concept. Witzel (2005) reveals that teaching with Concrete Representational Abstract (CRA) approach is a three-stage learning process in which students solve mathematical problems through the physical manipulation of concrete objects, followed by learning through pictorial representation of concrete object manipulations and ends with solving mathematical problems through abstract notation.

The CRA sequence is based on Bruner's (1966) stages that explained how children use representations to understand information. The enactive stage involves the use of objects without internal representation. During the next stage, iconic, children develop mental images of what they have manipulated and can visualize concepts in their mind. The last stage is the symbolic stage in which information related to representations can be stored in the form of symbols; symbols can be organized and classified. In addition to Bruner's stages, the CRA sequence is consistent with Pape and Tchoshanov's (2001) explanation of the role of representation within the development of mathematical understanding. Students interact with external representations that support their internal representations or understanding of concepts.

According NCTM (2000) representation is one of the standard mathematics learning processes that need to be grown and owned by students. The standard of this process should be presented not separately with mathematical material. Unfortunately, representations are often taught and studied as if standing alone without any connection in mathematics. In fact, representation is expected to support students' understanding of mathematical concepts and their relationship in communicating mathematics, arguments, and understanding of one another, in recognizing the relationship between mathematical concepts.

NCTM, (2000) notes that in the process of mathematics, there is a skill of thinking and heuristics which one example is giving representation in the form of diagrams, tables, mathematical equations, and others. In addition, in problem solving approach, there are several strategies might be introduced to the students, one of which is the strategy of making a diagram or picture. This helps students to disclose the information contained in the problem so that the relationships between components in the problem can be seen clearly. Creating an image or diagram is one example of visual representation. Thus it can be concluded that problem solving requires the ability of representation in the process.

Within the CRA sequence, children first learn mathematics operations through the manipulation of objects, forming conceptual understanding at the concrete level. At the concrete level, students form internal representations or make meaning through manipulation of objects (Miller and Hudson, 2006). The representational stage includes the use of pictures or drawings within computation. Students make their own representations of the operation and internalize the meaning of these representations and relations to other operations (Miller, Stringfellow, and

Kaffar, 2011). This is consistent with the call for fading concrete models (Ding and Carlson, 2013).

Studies also found out students complete operations using numbers only, associating previously formed representations with symbols. During the abstract stage, instruction builds on conceptual understanding and develops procedural knowledge and fluency. CRA research also includes mnemonic strategies; however, it is imperative that students achieve firm conceptual understanding prior to emphasis on procedural knowledge and fluency (Miller, Harris, Strawser, Jones, and Mercer, 1998).

One of the important roles of learning mathematics is to understand the abstract object of mathematics directly. At the age of elementary school children according to Piaget about 7 to 11 years, is a stage of concrete operational development, in this phase, the child can perform operations, and logical reasoning as long as reasoning can be applied to specific and concrete examples (Santrock, 2007).

Mercer and Miller (1992) used the CRA sequence to teach place value, and basic addition, subtraction, multiplication, and division to 109 students who struggled in mathematics. Through individualized instruction, students learned multiplication and division using plates and counters at the concrete level, pictures and drawings at the representational level, and a mnemonic strategy and numbers at the abstract level. In their study, they found out that students (n = 52) receiving CRA instruction in multiplication improved from scores of 43% to 91%. Students (n = 19) receiving CRA instruction in division improved from scores of 9% to 81%. Focusing on just division, Miller and Mercer (1993) used CRA to teach fifth grade students who struggled in mathematics. The researchers assessed student progress with 1-min timed assessments and students completed them with 100% accuracy. Other researchers used CRA to teach basic multiplication, but they provided initial instruction in general education inclusive settings rather than remedial settings (C. A. Harris, Miller, and Mercer, 1995; Miller et al., 1998). With regard to accuracy, students with disabilities and students who struggled with mathematics performed similarly to their peers without mathematics deficits.

According to the research cited by Terry Anstrom (2012), “students who use concrete materials develop more precise and more comprehensive mental representations, often show more motivation and on-task behavior, understand mathematical ideas, and better apply these ideas to life situations.” Research shows that using the CRA approach is very effective for students who have a learning disability in math (Anstrom, 2012). Students are more apt to gain and retain an understanding of math concepts when they are taught using CRA (Anstrom, 2012).

When adapting this theory within the practice of learning mathematics, it has been suggested that teachers first use real objects such as base-10 blocks .Cuisenaire rods, and cubes as medium for helping younger students discover and construct their knowledge in concrete ways (Hatfield et al., 2003).

Finally, most of the literature reviewed in relation to this objective show how the Concrete-Representation-Abstract model can be taught in classrooms to develop mathematics competences, however the gap identified is that there is limited evidence on how the approach has been used in classrooms to develop the mathematics competences and most especially in Africa and Uganda in particular which is the base for the study and therefore the researcher seeks to address this gap by investigating the relationship between the use of Concrete-Representation-Abstract and development of mathematics competences in Kira Municipality-Wakiso District.

2.4 Play and Development of Mathematics Competences

Early mathematical competencies are highly relevant for later education outcomes (Duncan et al. 2007; Grüssing and Peter-Koop 2008). Whilst there is a growing awareness that children need to already be supported in their mathematical learning in kindergarten, there is little consensus about the best pedagogical approach. Kindergarten educators may emphasise that mathematical activities need to be embedded in everyday situations (Gross and Rossbach 2011) or that early learning needs to be based on play, even though the understanding of play itself varies (Gasteiger 2015).

Despite the solid view that early mathematics is important, there is no agreement as to how preschool mathematics education should be conducted. Differences in opinion are visible both within and between countries, resulting in a plural view on preschool mathematics (Palmér and Björklund 2016). One of the most prominent differences regards the relation between play and teaching. On the one hand, there are paradigms emphasizing children's right to play, undisturbed by adults, for the sake of play itself (Sundsdal and Øksnes 2015), and on the other hand there is contemporary Nordic research developed within theoretical frameworks that emphasizes a consolidation of the two (Pramling and Pramling Samuelsson 2011; Pramling et al, 2017). The former paradigms often have philosophical underpinnings, as opposed to the latter paradigms' embracing preschool as part of the education system. According to Pramling et al (2017), they found that such dichotomies (between play and teaching) unfruitful and contradictory to the fact that many countries around the world include preschool children in the education system and that both teaching and play are central features of this practice.

Resnick, (2007) also noted that playful learning is a constructivist approach that promotes academic, socio-emotional, and cognitive competencies. Early mathematical thinking undergoes substantial development during the preschool and primary years. Developmental theory and research suggest that the building blocks of mathematical thinking arise from a variety of free play and guided play activities (Geary, 2006; Ginsburg, Lee, and Boyd, 2008). In this section, the researcher briefly reviewed the literature that links playful learning activities to the development of mathematical competences.

Play, in particular, represents a medium for promoting interest and mathematical thinking in a developmentally-appropriate manner (Ginsburg, Pappas, and Seo, 2001) For instance, research shows that learners naturally incorporate math concepts during free play, such as Counting, Adding, Taking away, Comparing and Grouping. Playful learning facilitates mathematical thinking, procedural fluency, and interest beyond traditional instruction methods. Griffin, (2003) suggests that mathematics should be viewed as a way of thinking rather than a set of facts and procedures to be learnt.

Play and playfulness are at the core of early childhood education (Singer 2013), although educators are not always aware of their role in fostering play (Bodrova 2008; Vu, Han, and Buell 2015). It is important to distinguish between activities, which are play-based and adult-initiated activities, which resemble school-like tasks (Bergen 2015). Weisberg et al. (2015, 10) coined educator-led educational activities disguised as play as ‘chocolate-covered broccoli’. Wood (2009) highlights the need to distinguish between the different forms on the continuum between free play and no play. Such a clarification is sought with the concept of ‘guided play’: ‘guided play sits between free play and direct instruction’ (Weisberg, Hirsh-Pasek, and Golinkoff 2013,

105) and consists of adults structuring of the play environment but leaving control to the children within the environment (Weisberg et al. 2015).

Innovative approaches to early mathematics could draw on play, be it role-play (van Oers 2010) or board and card games. It needs to be recognised that role-play, or pretend play, requires much time for the children to set up the play-frame, to engage with the play and develop it (Bergen 2015). As for board and card games, several studies found them to be effective in the acquisition of mathematical competencies (Gasteiger 2015; Jörns et al. 2014; Kamii and Kato 2005; Ramani and Siegler 2008; Schuler 2013). Gasteiger, Obersteiner, and Reiss (2015, 232) highlight that not only the concept of 'play' is deployed differently, but also 'games'; consequently, they propose a 'continuum from games designed for the purpose of entertainment only to targeted instruction with only few entertaining features'. Four aspects are essential to play-based approaches to mathematics in early childhood education: (i) the 'mathematical content needs to be part of the mechanics of the game'; (ii) needs to be 'correctly presented'; (iii) 'essential for further learning' and (iv) the game needs to be 'appropriate for the individual learning needs of the child' (Gasteiger, Obersteiner, and Reiss 2015).

Construction play seems so obviously mechanical, it's easy to think only of the development of practical engineering skills but kids also benefit from fantasy and make-believe. For example, experiments suggest that kids become more creative and inventive when they are exposed to stories about magic (Subbotsky et al 2010). Further to this, encouraging preschoolers to engage in imaginative, fantastical, pretend play may help them develop better executive function skills, like impulse control (Thibodeau et al 2016). Therefore if a child's block-play seems focused more on fantasy than engineering, he or she is still reaping important cognitive benefits.

Construction play helps kids develop engineering skills. It's easy to see how construction play could teach valuable lessons about architecture and engineering. Builders who create small-scale structures must cope with the same laws of physics that constrain the design of bridges and cathedrals. That's why engineers and scientists build physical models: It helps them test and explore their ideas. Studies also suggest that students learn best about physical forces when they experience them first-hand (Hayes and Kraemer 2017).

Other research has revealed links between a child's ability to recreate specific structures and his or her current mathematical skills (Verdine et al 2013; Oostermejier et al 2014; Richardson et al 2014). And a study in the Netherlands found that 6th grade students who spent more free time in construction play performed better on a test of mathematics word problems (Oostermejier et al 2014). In the previously-mentioned experimental study of preschoolers led by Sara Schmitt, the researchers found evidence that structured block play improved mathematical ability as well as cognitive flexibility. This, at any rate, was the case for children from homes of lower socioeconomic status (Schmitt et al 2018).

Studies also suggest that students learn best about physical forces when they experience them first-hand (Hayes and Kraemer 2017). English in their study suggest that if we want kids to develop an intuitive grasp of mechanical forces like the forces of tension and compression, construction play offers excellent learning opportunities. In one recent study, researchers taught 6th graders the principles of engineering through a hands-on program in the design and construction of earthquake-proof buildings (English et al 2017). Therefore it seems that toy blocks are an excellent educational investment.

Cooperative construction play helps kids improve social skills. Research suggests that kids become friendlier and more socially-savvy when they work on cooperative construction projects. For example, in studies of children with autism, kids who attended play group sessions with toy blocks made greater social improvements than kids who were coached in the social use of language (Owens et al 2008; Legoff and Sherman 2006). And research on normally-developing kids suggests that kids who work on cooperative projects form higher-quality friendships (Roseth et al 2009). Kids who are skilled with toy blocks tend to become better mathematicians. Block play has been linked with math skills, too. In one study, the complexity of a child's LEGO play at the age of 4 years had long-term predictive power: More complex play during the preschool years was correlated with higher mathematics achievement in high school, even after controlling for a child's IQ (Wolfgang et al 2001; 2003).

According to Caldera et al (1999), the kids who showed more interest in construction and built more sophisticated structures performed better on a standardized test of spatial intelligence. The same pattern has been reported by others (Oostermeijer et al 2014; Richardson et al 2014; Jirout and Newcombe 2015). But of course we can't assume that block-play *causes* children to develop superior spatial skills. Perhaps causation works the other way. Kids with advanced spatial skills may be more motivated to play with toy blocks.

Reports also reveal that Sweden is one example whereby early childhood education is available to all children aged one to six years, with a national curriculum that clearly states that the preschool practice is commissioned to ensure that children develop their competencies to their full potential. However, experiences from the Swedish context show that early childhood education is a delicate issue that needs further study (Swedish Schools Inspectorate 2016). As part of the education system, teaching is to be conducted in the Swedish preschool (Education Act 2010). At the same time, ‘a conscious use of play’ is emphasized as important in relation to children’s learning (National Agency of Education 2011).

The empirical material used is part of a larger research project aiming to investigate the teaching play relation in Swedish preschool practice. Mathematics as a content for learning is of special interest in this context, since while teachers in general claim that they teach mathematics in preschool (Björklund and Barendregt 2016), an evaluation by the Swedish Schools Inspectorate (2017) shows that mathematics teaching needs to be further developed in a majority of Swedish preschools.

Studies have found construction play is correlated to mathematics performance across development. The structural balance of construction play was correlated to mathematics performance (Casey, Pezaris, and Bassi, 2012). Creative play involves children exploring actions and materials and communicating their ideas. Through creative play children develop a variety of mathematical skills in meaningful contexts. For instance, children playing with junk and recycled materials can make models, explore the properties and characteristics of 2-D and 3-D shapes, investigate symmetry and tessellation and develop mathematical reasoning and problem-solving by constructing and deconstructing shapes.

The correlation between construction play and mathematics performance has been tested in preschool children. Children’s (3-year-olds) construction ability to build a model according to given instructions was correlated to early mathematics performance (Verdine et al., 2014). Another study observed the adaptivity and complexity of construction play in a preschool (3- to

4-year-old children) child care program, and analyzed the relationship with the participants' mathematics performance until secondary school (Stannard, Wolfgang, Jones, and Phelps, 2001).

Although construction play was not correlated to mathematics performance at younger years, construction play in preschool was correlated to mathematics performance in grade 7 (12-year-olds) and beyond. This could be evidence that construction play can be the developmental precursor to more complex mathematical processing only taught in higher years of schooling (Stannard et al., 2001). However, given the lapse of time and development between the observations of construction ability in preschool, and the measures of mathematics performance several years later, it is difficult to assess whether the findings relate specifically to construction play or as a result of general cognitive development, which was not tested. The relationship between construction play and mathematics performance has been established, and evidence shows the underlying mechanism of this relationship is visuospatial memory (Nath and Szűcs, 2014).

Physical play refers to physical, exploratory, manipulative and constructive play. It is the most common type of play in very young children (Montague-Smith and Price, 2012) as it involves bodily movements such as clapping, hopping and jumping. Through engaging in physical play experiences, children can learn a variety of mathematical concepts and skills. Physical play experiences include participating in games and activities that develop the vocabulary of position and movement; identifying and comparing shapes and patterns within the environment; exploring and manipulating materials and identifying their characteristics; and comparing sizes of objects and counting them. Through engaging in constructive play children develop mathematical skills such as problem-solving, visualisation, spatial awareness and reasoning, tessellation and pattern-making.

Pretend play encompasses make-believe, dramatic, socio-dramatic, role, fantasy and small world play. Pretend play involves children being creative and using their imaginations with objects, actions and in role-playing. Through participating in pretend play, children develop early literacy and numeracy skills. Through playing with real objects they develop mathematical skills and engage with concepts such as number operations related to counting, calculating, problem-solving, number, measure and time. Using objects to symbolise other things, children move from thinking in the concrete to thinking in the abstract (NCCA, 2009a).

According to Richardson et al., (2004), Children were also tested on Automated Working Memory Assessment measures of Visio-spatial and verbal short-term memory and working memory. Mathematical performance was measured through the WIAT-II Numerical Operations, and the Word Reading subtest was used as a control variable. Cognitive abilities of updating, shifting, and attention, along with IQ measures of WISC-III Block Design and Vocabulary were tested. Lego construction ability was significantly related to visuospatial working memory, Raven's CPM, Block Design and mathematics performance, but not to verbal memory, vocabulary, reading performance, or any of the executive function measures. This suggests that Lego construction ability is uniquely correlated with mathematics performance, and that this relationship is not driven by general cognitive ability or intelligence. Through mediation analysis following the recommendations of Baron and Kenny (1986) and Preacher and Hayes (2008), we found that the relationship between Lego construction ability and mathematics performance was uniquely mediated by visuospatial working memory and Raven's CPM. Spatial reasoning of

Block Design did not mediate the relationship between Lego construction ability and mathematics performance.

Play facilitates development of both numeracy and literacy skills amongst learners. In similar studies, it was noted that the numbers in the problems were not associated with particular quantities, did not have a magnitude that could be visualized or imagined, and thus could not be easily rank ordered." suggesting that the ability to connect numbers to quantities was not well understood or meaningful to them (Griffin, 2002).

Mathematical communication is an important tool that allows learners to demonstrate their mathematical thinking and understanding of mathematics. The National Council of Teachers of Mathematics (2000) emphasizes the critical importance of mathematical communication as a method to rationalize and to confirm children's mathematical thinking process to others.

The study examined the learner, the teacher and the environment in which constructive pedagogy can promote the development of mathematics competences. The learner in constructivist pedagogy should be interested, motivated, joyful, and confident and should be able to engage in communication and free play. While the teacher should be able to scaffold, guide and provide a conducive learning environment. The environment should cater for all dimensions of a child's developmental needs. It should also facilitate developmentally appropriate activities (Magret, 2014).

Ogunyemi and Ragpot (2015) observe that it is impossible to think about good mathematics pedagogy for children aged 3–8 years without acknowledging that much early mathematical learning occurs in the context of children's play. Therefore, learning is promoted by young children's engagement in play and how best they can support that learning (Boggan, Harper, and

Whitmire, 2010) comments that learning through play is seen as fundamental to good mathematics pedagogy in early childhood. Play is integral to a child's world; it becomes the gateway to engaging in mathematical inquiry.

Sarama (2009) suggests that mathematical experience can be narrowed down into two forms, play that involves mathematics and playing with mathematics itself. Further, it is the adult present during the play who is able to recognize how the children are representing their mathematics knowledge and then build on their understanding through prompting and questioning. The importance of well-planned, free-choice play, appropriate to the ages of the children, should not be underestimated. If such play is mathematized contributes to mathematics learning.

A classroom should have a variety of materials, such as crayons and paper, a block corner and wood-working and dramatic-play areas, communicates that symbolic activity, self-expression and social endeavors are valued. It should be loaded with materials that flow from one space to another and in which every inch of wall space is covered with posters or children's work is likely to be an over-stimulating environment (Skinner, 2006).

Yeo and Zhu (2005) recommend that classroom teachers try to establish a communicating environment for interaction that encourages students to verify, question, criticize, and assess others' arguments. Students in tune with the characteristics of good reasoning ask good questions. Ben-Hur (2006) says that students who perform poorly need to learn how to process mathematics and that they need instruction that targets the problem solving processes they fail to perform efficiently and that this instruction is too often absent.

In facilitating young children to construct their own mathematical knowledge, many teachers have considered a hands-on approach that involves the use of manipulative of helping children make connections to these concepts and scaffold to a more complex learning by providing them with opportunities to explore mathematics concepts and put them to practical use (Larbi, and Mavis, 2016).

There are numerous ways in which adults expose children to everyday learning experiences in mathematics. For instance, working with cars and measuring speed, measuring the ingredients in a cooking experience, building a tower with construction blocks of different dimensions, shopping and handling money (Boggan, Harper and Whitmire, 2010).

Ginsburg, (2006) recognised that not all playful activities lead to mathematical understanding. Research indicates that children do not always engage in mathematical learning opportunities as play can often be restricted by such contextual factors as lack of resources, curriculum overload, limited space, and class or group size (Kernan, 2007; McGrath, 2010). Children's dispositions, arising from their experiences, might also be implicated here (Dunphy, 2006), and some children may need encouragement and support to engage in a mathematical way in play, or in mathematical play. Another limiting factor may be the undervaluing of the potential of play by adults, who may be under pressure to provide evidence of specific types of learning (Wood and Attfield, 2005). These limitations also present pedagogical challenges for the educator who attempts to implement a play-based mathematics curriculum.

Finally, the relationship between mathematics competence and construction play is well established. Although previous research finds correlations with construction play and spatial abilities, we found the relationship between construction play and mathematics performance was mediated by visuospatial memory, independent of spatial ability in 7-year-old children. Although mediation analysis does not provide causal data, construction play may be a promising intervention tool for impairments in mathematics related to visuospatial memory. Using the Lego construction paradigm (Richardson et al., 2004) as an intervention tool allows task difficulty to be systematically increased in increments. Such intervention training raises the possibility of using Lego construction tasks to facilitate visuospatial memory, and mathematics performance.

In summary, several studies have been carried out on the development of early mathematics competences worldwide. However most of those studies do not directly address the aspect of constructivist pedagogy and development of mathematics competences although they investigate the development of early mathematics competences. The other gap discovered was that there was limited literature on the development of early mathematics competences in pre-primary schools in the African continent most especially in Uganda and it's against such a background the author went ahead to carry out the study on the topic so as to expound on the literature in Uganda.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the research design, data collection methods, study location, target population, sample size and sampling techniques, research instruments, measurement, validity and reliability, data collection procedure, data processing and analysis, and ethical considerations that were used in the study.

3.2 Research Design

The study involved the use of descriptive survey design and it entailed the use of both qualitative and quantitative methods of data collection. Descriptive survey design was used because it permits collection of information from participants at a single point in time. The design appropriately fits in the time allowed to undertake the study and it involved summarizing the information that was collected by use of tables and charts. On the other hand it involved explaining data collected into meaningful results that can easily be understood.

The design sought to determine a relationship between two (2) variables, the dependent variable (Mathematics competences) and the independent variable (Constructivist pedagogy).

3.3 Research Methodology

The study used a methodology triangulation (mixed method research) since it involved collecting, analyzing and interpreting data using both quantitative (positivist) and qualitative (interpretive) methods in a single study in order to investigate a phenomenon (Creswell, 2013;

Johnson and Onwuegbuzie, 2004). The research used instruments that included the interview guide and questionnaires to collect information from the respondents. The research employed both stratified and simple random sampling techniques to gather the information from the teachers and learners respectively. The findings were analysis and presented using tables and charts.

3.4 Study location

This study was conducted in Kira Municipality, in the selected pre-primary schools. Kira Municipality neighbours Kampala City but located in Wakiso District, Central region of Uganda. It is the country's second-largest Municipality by population. It is administered by Kira Town Council, an urban Local Government. Kira Municipality was chosen mainly due to the high numbers of pre-primary schools within Wakiso district.

3.5 Target Population

In Kira Municipality, Wakiso District, there are over 167 pre-primary Schools. The study population was drawn from 10 Schools with 143 teachers and 706 leaners in pre-primary School. The researcher chose this population because the sample would provide reliable information required for the study.

Table 3.1: Sample population

School	No. Of teachers	No. Of learners in top class2018	No. Of learners in primary 2019	No. Of learners who did not measure to the set expectation
A	30	250	200	98
B	20	150	90	70
C	15	100	80	43
D	14	70	44	26
E	15	90	75	32
F	10	56	50	20
G	12	60	55	15
H	10	45	39	11
I	8	40	38	12
J	9	50	36	14
Total	**143**	**911**	**706**	**341**

3.6 Sampling size and Sampling Techniques

3.6.1 Sample size

Determination of sample size from a given population is usually difficult in any research. Sample size determination can be done in many ways such as use of formulae or by use of table; in this research the researcher intends to employ specifically sample size determination table by Krejcie and Morgan (1970). The reasons for the use of this table is because of its being easy to determine the sample, it is also an internationally recognized and tested method of determining samples whose inferred results are similar to the one of the population and lastly it does not give fractional respondents as it is the case with other methods.

Table 3.2: Sample size

Sample categories	Sample Population	Sample size	Sampling Technique
Pre-school teachers	143	100	Stratified simple random sampling
Headteachers	30	10	Purposive sampling
Pupils	706	500	Simple random sampling
Total	**873**	**610**	

Source: Krejcie and Morgan 2010

3.6.2 Sampling Techniques

A sample is a portion that is extracted from the sampled population for the purposes of investigation and inferring the results to the population.

This study used both stratified random and simple random sampling techniques. The simple random method was used because it eliminated biasness and therefore allowed learners to have an equal chance of participating in the study. The researcher used stratified random sampling to obtain specific information from the teachers.

3.7 Research Instruments

This research used observation, questionnaires, interviews and documents to collect data from respondents that included classroom teachers and students.

3.7.1 Observation

The classroom environment was observed to determine the kinds of manipulative instruction materials, the teaching activities that constitute constructive pedagogy such as child interaction, child participation and child to child interaction. Observations were done on different days and at different times, usually between 08:00am and 10:00am: each of the observation sessions lasted for about ten minutes.

3.7.2 Questionnaire

The researcher used a semi-structured questionnaire, with both open and close-ended items. This tool was used because of its advantage in collecting complete data in a logical flow since it provides the respondents with environment to express themselves freely and the fact that it can help to expedite the process of data collection from a relatively bigger sample size. Questionnaires were administered to the class teachers, administrators of schools (head teachers) and district officials. The closed format questionnaires with multiple choices were administered to the head teachers of the pre-schools.

3.7.3 Interview guide

The interview guide was used to collect information from the Key informants who knew what was going on in the pre-schools. The purpose of key informant interviews was to collect information from senior teachers and head teachers who had first-hand knowledge about the mathematics process skills and constructivist pedagogy. These teachers, with their particular knowledge and understanding, provided insight into the nature of manipulatives and their usage and gave recommendations for solutions.

3.7.4 Document review checklist

The researcher used a document review checklist in order to get information from the documents and records. This was done in an effort to ascertain the approaches being used in the development of mathematics competences and use of constructivist pedagogy. Children's books were used to reveal how they arrive at the answers, timetables showed how frequently mathematics was taught, and Mathematics curriculum was used to ascertain whether the teacher was on track with the early childhood policy guidelines.

3.8 Measurement

The dependent and independent variables were measured using self-constructed questionnaires. Objective one was measured using nominal scale which applied to a common set of characteristics on manipulative constructive materials are used in problem solving competence (Amin, 2005).

For objective two and three the researcher used a five point scale ranging from 1 to 5. The respondents indicated their levels of development of mathematical competences in Pre-Primary schools by ticking appropriate answers on scale. The likert scale was used to collect opinion and this was used to measure the respondents' perception on development of mathematics competences in Pre-Primary schools.

3.9 Validity and Reliability

This refers to the ability of a tool to give true answers as expected from the asked questions which can be generalized to other populations (Kombo and Tromp, 2009).

For face validity, the instrument was reviewed by the supervisor who made comments on the tools. After making the comments the researcher adjusted tools appropriately deleting irrelevant questions and added in one deemed relevant questions.

The researcher used the CVR (content validity ratio) proposed by Lawshe (1975) as a linear transformation of a proportional level of agreement on how many “experts” within a panel rate an item “essential” calculated in the following way:

$$CVR = \frac{n_e - (\frac{N}{2})}{\frac{N}{2}}$$

Where CVR is the content validity ratio, n*e* is the number of panel members indicating “essential, “and N is the total number of panel members. The final evaluation to retain the item based on the CVR is depends on the number of panels. For this study, the obtained validity coefficient was 0.814 and since it was greater than 0.7 as recommended by Amin (2005), the instruments were adopted with minor amendments.

3.9.1 Reliability

The researcher also ensured that the instruments being used were reliable. Reliability of the tool was the ability to provide consistent results from various tests (Kombo and Tromp, 2009). The reliability of the tools was ascertained through a pre-test exercise. The tools were printed and pretested among teachers in pre-primary schools in Kira Municipality. These were asked to rate the question as relevant or irrelevant.

The researcher used Cronbach’s alpha a measure of internal consistency that is, how closely related a set of items are as a group be performed. Cronbach’s alpha can be written as a function of the number of test items and the average inter-correlation among the items. Formula for Cronbach's alpha:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Here N is equal to the number of items, c-bar is the average inter-item covariance among the items and v-bar equals the average variance. The conducted test to establish the reliability aspects of the tools showed a reliability alpha of 0.702. Sekaran argues that for an instrument to be considered reliable, the reliability alpha should be 0.5 or above. Since 0.702 was above 0.5, the instrument was upheld, on account of the fact that it was considered reliable.

3.10 Data Collection Procedure

Before the start of this study, permission was requested and obtained by the student from Kyambogo University (Appendix 1). This permission was in form of an introductory letter from the Post Graduate School, which was presented to the Headteachers of the identified primary schools in Kira Municipality with the reason to be accepted to interface with respondents. The researcher also got approval from Kira Municipality Education Department. Arrangements were made with the respondents and the researcher was able to obtain informed consent prior to conducting the interviews.

3.11 Data Processing and Analysis

The first step in any quantitative data analysis is to identify the levels or scales of measurement. In this study, ordinal and interval scales were used since the study was quantitative in nature. Quantitative data was therefore coded entered into excel and exported to SPSS for data analysis and descriptive statistics were employed to summarize and identify patterns in the data as presented on the tables and charts. Descriptive statistics used included; frequencies, percentages, mean and standard deviation.

Specifically, analysis of data for each objective was done as follows;

- Objective one was to explore manipulative materials was analyzed using content analysis method and descriptive statistics method. Data were presented using frequency tables.
- Objective two was to examine the relationship between the use of Concrete-Representation-Abstract and development of mathematics competences in the selected pre-primary schools. It was analyzed using both descriptive statistics, where frequency counts and percentages were computed.
- Objective three was assess the use of play in developing mathematics competences among pre-primary school learners.

Qualitative data analysis was employed and a manual analysis was conducted. Every interview transcript was filed and analyzed. Manual analysis was used in analyzing the themes of the data generated from Key Informant. The findings of the data analysis were necessary in finding a common ground of discussion. Analyzing involved re-reading the interview transcripts to identify themes that emerged from the respondents' answers during interviews with the key informants who were the Pre-Primary school teachers. The researcher used the topics and questions in the interviews to organize the analysis, in essence synthesizing the answers to the questions proposed. If the interviews on constructivist pedagogy raised more questions than they answered, then more interviews were necessary to properly examine the issue at hand. Verifying involved checking the credibility of the information gathered and a method called triangulation was used to achieve this purpose. Triangulation involved using multiple perspectives to interpret a single set of information.

3.12 Ethical Considerations

For this study ethical consideration included; voluntary and informed consent, confidentiality, anonymity, non-maleficence, beneficence, plagiarism and fabrication and falsification.
Voluntary: The researcher ensured that the participants who were involved in the study participated at free will and were not forced.

Informed consent: First, the researcher got clearance letter from the Post Graduate School as an introduction to the respondents before going out to collect data. Before commencing the research, permission was obtained from all relevant authorities including the District officials, the school principal and the School Governing Board.

Confidentiality: The researcher promised the participants that the information given would only be used for the study purpose and would be revealed to any other persons. The researcher further ensured that the names of the participants were not revealed which included the teacher, head teacher and the children.

Anonymity: There was protection of the information given in confidence by the respondents. Names of respondents were not provided in the study. Identification of participants by numbers or letters i.e. "R1" meaning Respondent 1 or "RA" meaning Respondent was instead adopted.

Non-maleficence: The researcher guarded against any intentional harm to minimize any aspect of potential harm by refraining from injuring the respondent either physically or psychologically.

Beneficence: In this study, the researcher did not exaggerate or even understate the benefits of the research to be carried out.

Plagiarism: In this regard, the researcher acknowledged all the information sources where the ideas are obtained and also gave proper references to the cited work.

Involvement of the young children: The researcher ensured that the young children given free opportunity to demonstrate on the competences of mathematics manipulative materials, play, and Concrete-Representation-Abstract while ensuring that the process does not endanger their lives.

CHAPTER FOUR

FINDINGS, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter gives a presentation of the study findings on constructivist pedagogy and development of mathematics competences: A survey of pre-primary schools in Kira Municipality. The findings are presented according to the study objectives which were to; explore the mathematics manipulative materials used in developing mathematics competences in the selected pre-primary schools, examine the use of Concrete–Representational-Abstract (CRA model) in development of mathematics competences in the selected pre-primary schools, and assess the use of play in development of mathematics competences among pre-primary school learners.

4. 2 Mathematics Manipulative Materials and Development of Mathematics Competences

The purpose of this objective was to make a detailed analysis of the manipulative materials used in the teaching of mathematics competences in the selected pre-primary schools in Kira Municipality. In both descriptive and hypothetical manner, results of the objective were obtained from class teachers, leaners and head teachers in the selected pre-primary schools.

In this specific objective, respondents were given to name the mathematics manipulatives in the questionnaire they considered applicable in their situation. The findings were as indicated in Table 4.1.

Table: 4. 1: Manipulative Materials used to Develop Mathematics Competences.

Manipulatives	Frequency	Percentage
Counting sticks	84	98
Number cut outs	73	85
Geometric blocks	31	36
Toy blocks	23	27
Pattern blocks	33	38
Bottle tops	77	90
Shape cut outs	62	72
Abacus	57	66
Wooden beads	26	30
Strings	61	71
Playing cards	59	69
Measuring cups	12	14
Number cubes	19	22

Source: Field data

Table 4.1 revealed that out of the 86 teachers, who were involved in the study, majority of them (98%) considered counting sticks to be the most common manipulative materials used to teacher learners mathematics competences in their classrooms, followed by 90% who considered bottletops and the least population considered measuring cups and they constituted only 14% of the respondents. The findings also revealed that there were other manipulative materials used to teach learners mathematics competences and they include; number cut outs that constituted 85%, shape cut outs 72%, strings 71%, playing cards 69%, abacus 62%, pattern blocks 38%, geometric blocks 36%, wooden beads 30% and number cubes 22%. The results revealed that all schools used more than four different manipulative materials to teach learners mathematics competences in their respective schools.

Interviews with the key respondents who were the head teachers revealed that they used only physical manipulatives and they didn't have the virtual manipulatives in their schools and so could adopt them in classrooms. The respondents further revealed that most of the teachers in their schools used counting sticks, bottle tops and shape cut outs to teaching the learners counting skills, subtraction, addition and mathematics thinking.

Using observation method, the author observed that all the nursery schools that were involved in the study used only the physical manipulatives to teach mathematics competences. The author further observed only one school where learners used measuring cups in sand play and water. This study was consistent with that of (Margret, 2014) who found out that Froebel in 1937 used physical manipulatives like geometric blocks and pattern activity blocks to teach mathematics in kindergarten. The author further observed that some of the learners were not able to relate manipulatives with mathematics representation during the lessons. This implies that not all learners are able to relate the knowledge of manipulatives to mathematics representations which makes it difficult to help such learners.

4.2.1 The Outcome of Manipulatives on Learners' competences in Mathematics

It was necessary to understand the outcome of using manipulatives in the teaching of mathematics competences to the learners. The teachers were required to give the views basing on their experience in teaching early learners using different manipulative materials, how they have generally impacted on the learners' competences in mathematics and their responses were as presented in table 4.2.

Table 4.2 The Outcome of Manipulatives on Learners' competences in Mathematics

Competences	Frequency (n)	Percentage (%)
Enhances learners with counting skills	71	82.6
Develops mathematics thinking	46	53.5
Promotes representation skills	56	65.1
Measurement skills	12	14.0

Source: ***Primary data***

Table 4.2 revealed that 82.6% of the respondents considered the manipulatives to be impacting on the learners in a way that they enhance the learners with the counting skills and they constituted the highest population of the respondents, followed by 65.1% who considered developing mathematical thinking among learners and only 14% considered the manipulatives to have equipped the learners with measurement skills. This results imply that manipulatives positively impacts on the mathematics competences among learners in pre-primary schools.

Close interviews with the headteachers of the selected schools revealed that majority of the learners in their schools mainly gained counting skills, and mathematics reasoning skills. The key respondents further revealed that the learners who had attained the mathematics skills through the use of manipulatives were able to improve on their performance in mathematics.

The study also further revealed that the authors was able to observe learners count from 1-10 with the help of counting skills and therefore implies that manipulatives greatly improves on the learners counting skills. This study coincided with that of Seefeldt and Wasik, (2006) who mentioned that materials should "foster children's concepts of numbers and operations, patterns, geometry, measurement, data analysis, problem solving, reasoning, connections, and representations.

4.2.2 Challenges Faced in Accessing the Different Manipulative Materials

The author found it important to ask the respondents whether they faced any challenges in accessing different manipulative materials in classrooms, the respondents were then give two responses to choose from and their responses were as presented in table 4.3.

Table 4.3: Response to the Challenges Faced in Accessing Different Manipulative Materials

Response	**Frequency (n)**	**Percentage (%)**
Yes	71	82.6
No	15	17.4
Total	**86**	**100.0**

***Source:* Survey Data, 2019**

Table 4.3 summarizes the responses to the challenges faced in accessing different mathematics manipulative materials and the results revealed that 82.6% of the respondents agreed that they faced challenges and they constituted the high number of respondents while only 17.4% disagreed. An interview with the key respondents also revealed that they several faced challenges accessing different kinds of manipulatives in their schools.

Table 4.4: Challenges Faced in Accessing Different Manipulative Materials

Challenges	**Frequency**	**Percentage**
High costs of some manipulatives	58	67.4
Limited storage facilities for materials	39	45.3
Low quality of some manipulatives	25	29.1
Scarcity of some manipulatives in the market	43	50.0

Source: **Survey Data, 2019**

Table 4.4 summarizes the challenges that are faced by trainers in accessing different manipulative materials in classrooms. The results revealed that majority of the respondents (67.4%) considered high costs of some manipulatives to be the major challenge faced in the accessing manipulative materials in classrooms, followed by 50% who considered scarcity of some manipulatives in market and only 29.1% considered low quality of some manipulatives which affected teaching of mathematics competences to the early learners. The results further revealed that there were also those who considered limited storage facilities of materials in classrooms and they constituted 45.3% of the respondents. The results imply that early failure to develop mathematics competences was because of the challenges faced by their teachers in accessing manipulative materials that could easy their ability to develop the competences through practical engagement in the learning process.

An interview with key respondents revealed that they majorly faced challenges of high cost of purchasing the manipulatives. They further revealed that some of the materials were scarce in the market like the virtual manipulatives and that most of their teachers never had the skills to use the virtual manipulatives in classrooms which makes it difficult for them to adopt them.

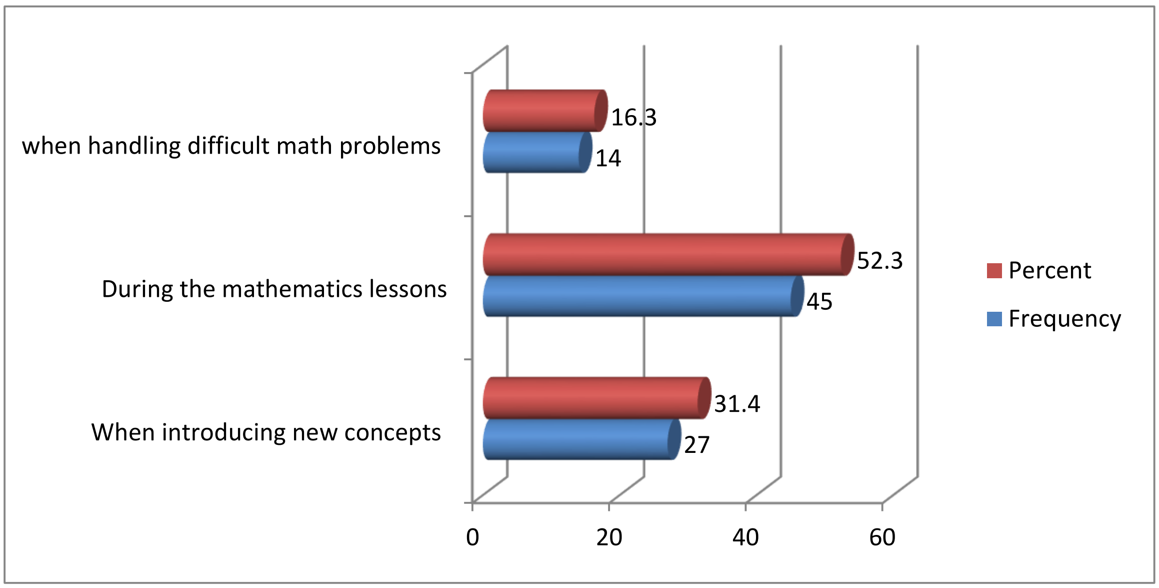
The researcher also revealed that during an interview, one of the key respondents pointed out that some teachers do not have creativity to improvise the manipulative materials. These findings therefore contradicts that of Anderson, J., Reder, L., and Simon, H. (2000), who mentioned that many different manipulatives are commercially available, and it is also possible to make them using common objects, such as craft sticks, beans, or buttons and Cope, (2015) who argued that physical manipulatives range from low-cost, simple, everyday items, such as buttons, paper clips, tooth picks, dominoes, money, string, playing cards, rulers, number cubes, graph paper, empty egg cartons, measuring cups, and film canisters to more complex and discipline-specific items, such as calculators, two-color counters, thermometers, decimal tiles, pattern blocks, Cuisenaire rods, geo-boards, tangrams, algebra tiles, and pantomimes

The author using observation method found out that none of the schools had virtual manipulatives and is believed to be increasing mathematics competences among several learners in developed economies as revealed by several studies such Reimer and Moyer, (2005) who mentioned that using several virtual manipulative fraction applets during a 2-week unit on fractions indicated a statistically significant improvement in learners' conceptual knowledge and a significant relationship between learners' scores on the posttests of conceptual knowledge and procedural knowledge in mathematics.

4.2.3: Application of Manipulatives in Teaching of Mathematics Competences

The application of manipulatives in teaching mathematics competences according to this study considers how often the manipulatives are used in classrooms by the teachers to teach mathematics and this differs according to the teachers and therefore the author sought to find out how often each of them used the manipulatives and the results were as presented in the figure 4.1.

Figure 4.1: Application of Manipulative Materials in Teaching of Mathematics Competences



***Source:* Survey Data, 2019**

Figure 4.1 revealed that 52.3% of the respondents considered that they use the manipulatives during mathematics lessons, followed 31.4% who considered when introducing new concepts and only 16.3% considered when handling difficult mathematics problems. These results therefore imply that different teachers use manipulatives in teaching of mathematics competences to learners during different lesson schedules and time intervals.

An interview with the key respondents revealed that teachers in their schools used manipulatives during the mathematics lessons. This finding was contradicting with that of Moyer (2001) who found out that Indonesian teachers usually use manipulatives just if they have extra time. However, it coincides with the theories of learning by Piaget, Brunner, and Ausubel that suggest that it is important to present concrete objects in mathematics learning such that the learning becomes meaningful, and therefore, the students could easily understand the concepts and are not easily forgotten (Furner and Worrell, 2017; Cockett and Kilgour, 2015; Larbi and Mavis, 2016).

The results from observation reveal that the researcher was able to observe 75.6% of the teachers using some manipulatives during the mathematics lessons, those manipulative materials included; counting sticks, shape cut outs and wooden beads to develop the mathematics competences among learners.

4.2.4 Results from a pretest exercise

The researcher during the study carried out a pre-test exercise to investigate the relationship between the use of manipulatives and students' performance. The results of the pre-test exercise were run using an independent sample test and the findings were as presented in table 4.5.

Table 4.5: Relationship between the use of Manipulatives and Students' Performance

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Performance	Equal variances assumed	4.202	.043	-7.490	95	.000	-21.76063	2.90518	-27.52814	-15.99312
	Equal variances not assumed			-7.506	92.029	.000	-21.76063	2.89913	-27.51852	-16.00273

Source: **Survey Data, 2019**

Table 4.5 shows the results from an independent sample t test that was run to find the relationship between use of manipulatives and students' performance in mathematics. The Levene's test for equality of variances shows that the variance of the performance in mathematics is significantly different between the students who use manipulatives during the mathematics lessons and those who use manipulatives when handling difficult mathematics problem since the $p<0.05$.

The t-test for equality of means shows that the mean marks of learners in mathematics is significantly different between the learners' who use manipulatives during the mathematics lessons and those who use manipulatives to solve difficult mathematics problems ($t_{-7.506}$, $p<0.05$).

The average performance of learners who use manipulatives when handling difficult mathematics problems is less by 21.76063 than the average of learners who use manipulatives during the mathematics lessons.

4.3 Concrete-Representational-Abstract (CRA) model and developing mathematics competences

This study objective was designed with intent to make an analysis of the use of Concrete–Representational-Abstract (CRA) model and developing mathematics competences among pre-primary children in the selected schools. There were several guiding questions on this objective used to collect information from the respondents concerning the use of the approach and development of mathematics competences and the results were as presented.

4.3.1: Response on the Application of Concrete-Representation-Abstract in Classrooms

The study found it necessary to find out from the individual teachers whether they apply Concrete-Representation-Abstract model in classrooms. This refers to the use of the model by the teachers to develop mathematics competences among learners and their responses were as present in table 4.6.

Table 4.6: Response on the Application of Concrete-Representation-Abstract in Classrooms

Response	Frequency	Percentage
Yes	48	55.8
No	38	44.2
Total	**86**	**100.0**

***Source:* Field Data, 2020**

Table 4.6 revealed that 55.8% of the respondents agreed that they used CRA model to develop mathematics competences among the early learners and they constituted the highest population of the respondents and 44.2% disagreed that they used the model. An interview with the key respondents revealed that the teachers who taught baby classes and middle classes never used the model according the sequence, they further revealed that most of them used only the concrete and representation stages to teach the learners mathematics and that only the teachers who taught the Top classes were able to use the model fully. This therefore implies that early learners in

Baby and Middle classes develop mathematics competence using the concrete and representation stages.

The results from observation found out that teachers in Baby and Middle classes used concrete materials and representations in classrooms to teach mathematics. The researcher didn't observe the use of abstract stage in any of the classrooms in all the selected pre-primary schools.

4.3.2 Stages When the Model is Applied in Classrooms

This refers to the different stages where the teachers always apply the model to teach mathematics to the learners. Different teachers always used the model to teach mathematics according to their preferences, some prefer during difficult mathematic problems, others when introducing new concepts and some generally during the daily mathematics lessons. The author therefore sought it wise to find out at what stages and whether the stages at which they are used had an impact on the development of mathematics competences among the pre-primary learners and their responses were as presented in table 4.7.

Table 4.7: Stages when the model is applied in classrooms by teachers

Time schedule	Frequency	Percentage (%)
During daily mathematics lessons	11	22.9
When introducing new concepts	21	43.8
When encountering difficult mathematics problems	16	33.3
Total	**48**	**100.0**

Source: **Field Data, 2019**

Table 4.7 shows that out of the 55.8% of the respondents who agreed that use CRA model in developing mathematics competences among the pre-primary learners, 43.8% considered using the model when introducing new concepts and they constituted the highest population of the respondents, followed by those who considered when encountering difficult mathematics problems and they constituted 33.3% of the respondents and only 22.9% considered during mathematics lessons. An interview with the key respondents revealed that most of their teachers used the approach when introducing new concepts because the approach can best help the learners to understand and remember the concepts that are being introduced to them since they are able to them practically through stages. This therefore implies that the approach is best when introducing new concepts and this study was consistent with that of Witzel, (2005) argued that the use of manipulatives increases the number of sensory inputs a student uses while learning the new concept, which improves the chances for a student to remember the procedural steps, needed to solve the problem.

The results from observation revealed that the author was able to observe different stages of the model being used in top classes in the different selected pre-primary schools. The study further revealed that the researcher was able to observe two classes using abstract stage, four using the concrete stage and four using representations in class.

4.3.3 Outcome of the Approach in Development of Mathematics Competences

This refers to the extent to which the approach causes change in the level of mathematics competences among the early learners. The researcher therefore sought the opinion of the respondents and their responses were as presented in table 4.8.

Table 4.8: Outcome of the Approach in Development of Mathematics Competences

Impact	**Frequency**	**Percentage (%)**
Learn and Remember new concepts taught	23	47.9
Enables learners to solve difficult mathematics problems	31	64.6
Improves on the learners mathematics reasoning	26	54.2
Improves on the learners representation skills	42	87.5
Enables the learners to identify mathematics symbols	19	39.6

Source: ***Field data***

Table 4.8 shows that majority of the respondents 87.5% considered the use of Concrete-Representation-Abstract model to be improving on the learner's representation skills, followed by 64.6% who considered the model to be enabling learners to solve difficult mathematics problems and those who considered the model to be enabling learners identify mathematics symbols constituted the least population. The study further more revealed that there other respondents who considered improving on the learners reasoning and remembering of concepts taught constituting 54.2% and 47.9% respectively. This therefore implies that each stage of the model plays an important role in the learning of mathematics among the early learners.

An interview with key respondents revealed that majority of the learners who are taught using this approach in their sequences were able to improve on their mathematics competences for instances concrete stage was able to teach learners new concepts and the representational stage developed representation skills and therefore improving on the scores in the mathematics assessments.

The results from observation of the pretest assessment given to the children in top class revealed that majority of the learners who had developed representation skills were able to score 70% and above in the assessment. This study therefore was consistent with that of Miller, Stringfellow, and Kaffar, (2011) who argued students make their own representations of the operation and internalize the meaning of these representations and relations to other operations in mathematics.

Table: 4.9: Response to the Categories that are benefited more from the CRA Model

	Frequency (n)	**Percentage (%)**
Yes	52	60.5
No	34	39.5
Total	**86**	**100.0**

***Source:* Primary data, 2019**

Table 4.9 shows that 60.5% of the respondents agreed that Concrete-Representation-Abstract model benefited some category of learners more than others. They further proceeded and revealed that the approach majorly benefits children with learning disability because they consistently participated in the representation stage which helped them to learner the mathematics concepts. The respondents who disagreed constituted 39.5% of the respondents. This therefore implies that the approach helps learners with learning disabilities to develop mathematics competences probably because the approach is practical and so therefore they are not left out compared to the theoretical. Interviews with key respondents revealed that majority of the children with learning disability in mathematics who were taught using this approach were able to improve on their performance in mathematics. One of the key respondents in one school said that *"the children with learning disability actively engage in learning using this approach and sometimes outstrip the children without learning disability in mathematics"*.

The researcher furthermore was able to observe the learners with disability participating in one of the class while using the representation. The learners were able to use oranges to represent the mathematical concepts of subtraction and addition. These study findings therefore coincided with the arguments of Anstrom, (2012) who mentioned that using the CRA approach is very effective for students who have a learning disability in math. Students are more apt to gain and retain an understanding of math concepts when they are taught using CRA (Anstrom, 2012).

4.3.4 Pre-test Results for Relationship Between the Use of CRA Model and Performance in Mathematics

The researcher also carried out a pretest exercise to find out the relationship between the use of CRA Model in the teaching and learning of mathematics and learners' performance. The results were obtained and an independent sample test was run to provide an analysis of the performance and the findings were as presented in table 4.10.

Table 4.10: Relationship Between the Use of CRA Model and Performance in Mathematics

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Performance	Equal variances assumed	.193	.662	6.135	85	.000	18.78703	3.06232	12.69832	24.87574
	Equal variances not assumed			6.229	81.590	.000	18.78703	3.01588	12.78703	24.78703

Source: **Survey Data, 2019**

Table 4.10 shows the results from an independent sample t test that was run to find the relationship between use of CRA Model and students' performance in mathematics. The Levene's test for equality of variances shows that the variance of the performance in mathematics is not significantly different between the learners who used CRA Model when introducing a new concept in the learning of mathematics and those who used the model when handling difficult mathematics problem since the $p<0.662$ is greater than the chosen $\alpha = 0.05$.

The t-test for equality of means shows that the mean marks of learners in mathematics is significantly different between the learners' who used CRA Model when introducing new concepts in the learning of mathematics and those who used the model to solve difficult mathematics problems ($t_{6.135}$, $p<0.05$).

The average performance of learners who used the CRA Model when introducing new concepts in the learning of mathematics is higher than the average of learners who used model when solving difficult mathematics problems by 18.78703.

4.4 Play and Mathematics competences

The purpose of this objective was to make an assessment the use of plays in developing mathematics competences. Teachers who provide foundation in learning in pedagogy skills were asked several questions in relation to the use of plays in support of constructivist pedagogy and several responses were received.

4.4.1: Use of Play in Development of Mathematics Competences

The teachers in this section were asked whether they use plays in mathematics classrooms. The purpose of this question was to assess whether the teachers used plays to develop mathematics competences among learners and their responses were as indicated in table 4.11.

Table 4.11: Response to the Use of Play in Classrooms to Develop Mathematics Competences

Response	Frequency	Per cent
Yes	54	62.8
No	32	37.2
Total	**86**	**100.0**

***Source:* Survey Data, 2019**

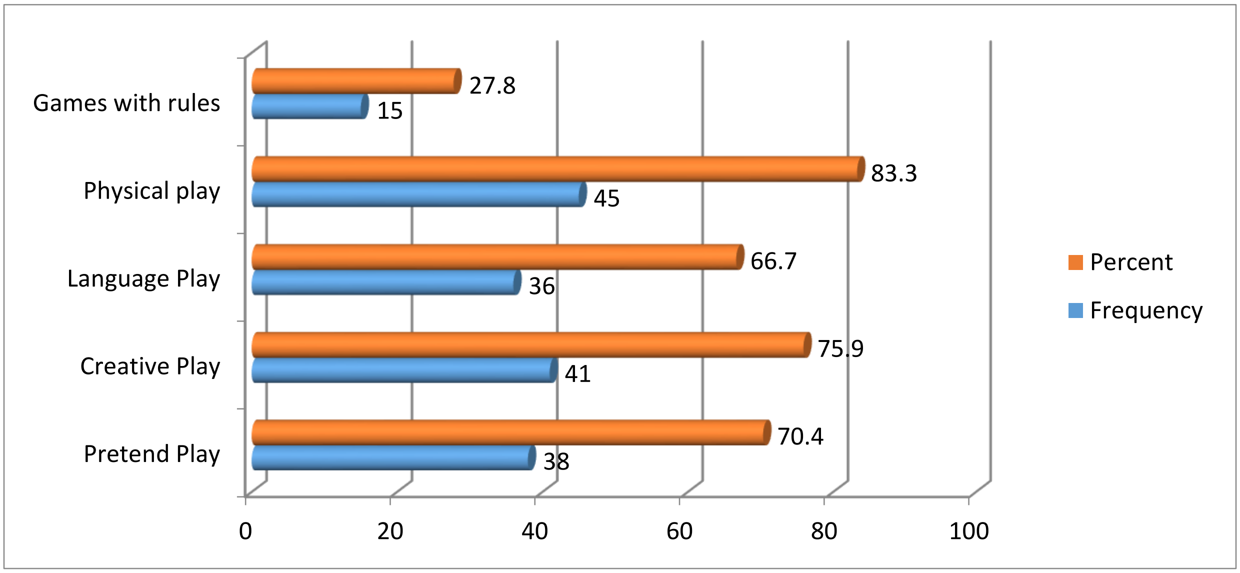
Table 4.11 shows that 62.8% of the respondents agreed that they used play in classrooms to develop mathematics competences and they constituted the highest number of respondents while those who disagreed constituted 37.2% of the respondents. Focus group discussions with the respondents who disagreed revealed that they used plays to develop competences in English language that involved developed of spoken English among learners to improve their communication skills. Interviews with the key respondents revealed that only some teachers used plays to develop mathematics competences. One of the respondents said that *“some teachers used plays to develop competences in subjects like English language that improved learner’s communication skills”.*

The researcher further during the study observed some teachers using sand play and water to develop mathematics competences. The learners were able to measure sand and water in their measuring cups and pour them in another location while counting and these learners were able to learn counting skills using the plays. The researcher also observed some learners use dramatic plays though there were not related to mathematics concepts but rather communication skills in English language.

4.4.2 Types of plays used to Develop Mathematics Competences

This study found it very crucial to find out the types of plays that are used by teachers to develop mathematics competences among the early learners. The teachers were therefore asked to indicate the types of plays they employed in classrooms and their responses were captured as presented in 4.2.

Figure 4.2: Types of Play used to Develop Mathematics Competences



Source: **Survey Data, 2019**

Figure 4.2 shows that majority of the respondents (83.3%) revealed that they mainly used physical plays to develop mathematics competences among early learners, followed by (75.9%) who considered creative play and only (27.8%) considered games with rules play and they constituted the least population of the respondents. The findings further revealed that there were also some respondents who considered pretend play and language play and they constituted (70.4%) and (66.7%) respectively. The results further revealed that each respondent considered using more than two types of play to develop mathematics competences among learners. An interview with the key respondents revealed that the most common used plays were the one that they majorly had available in the school and easy to maintain. For example one of the respondents said that *"we majorly use physical plays because they are the ones that are most commonly available compared to the others".*

Researcher further observed that learners apply the mathematics concept of takeaway, counting, grouping and addition during physical play lesson held in one of schools. This therefore implies that plays are very helpful in development of mathematics competences like addition, subtraction and grouping among learners and this finding was in agreement with that of Ginsburg, Pappas, and Seo, (2001) who argued that Play, in particular, represents a medium for promoting interest and mathematical thinking in a developmentally-appropriate manner. For instance, they found out that research shows that learners naturally incorporate math concepts during free play, such as Counting, Adding, Taking away, Comparing, and Grouping.

4.4.3 Outcome of using Play in Classrooms on Learners Performance in Mathematics

This study also took a look at the impact of using plays in classrooms on the learner's performance in mathematics. The teachers were asked to give their opinions on how the use of plays has affected the performance of their learners in mathematics and their responses were as presented in table 4.10.

Table 4.12: Outcome of using Play in Classrooms on Learners' Competences in Mathematics

Impacts	Frequency	Percent
Improve mathematical thinking of learners	35	64.8
Enhance learners with counting, takeaway and adding skills	49	90.7
Enable learners to connect numbers to quantities	41	75.9

Source: **Survey Data, 2019**

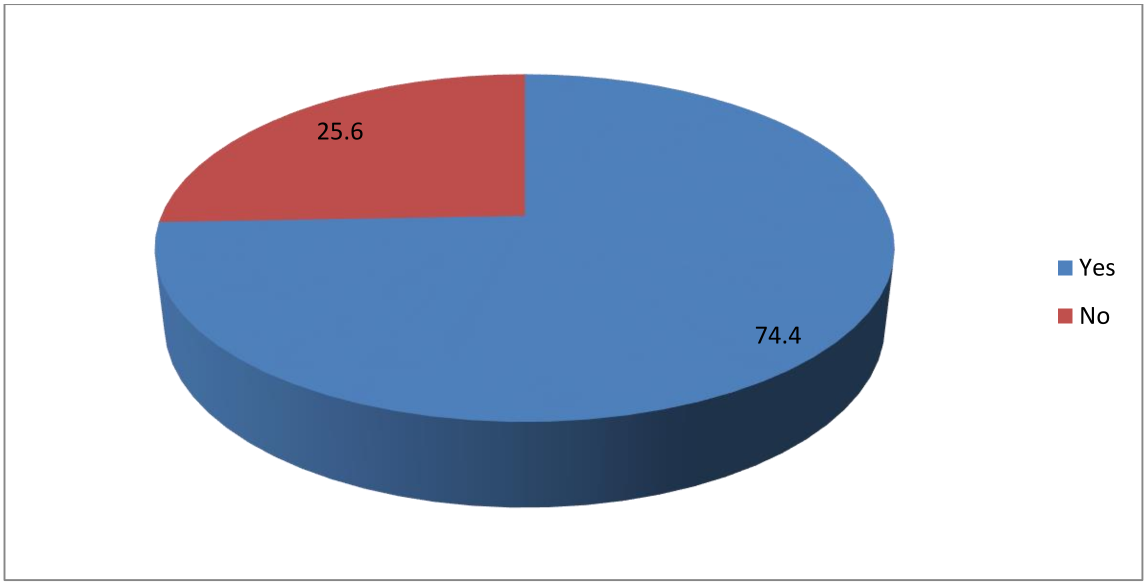
Table 4.12 shows that 90.7% of the respondents revealed that the use of plays in classrooms enhanced learners with counting, takeaway and adding skills and they constituted the highest population of the respondents, followed by 75.9% who considered enabling learners to connect numbers to quantities and 64.8% of the respondents considered improving learners' mathematical thinking and they constituted the least number of respondents. The results further revealed that atleast 68.5% of the respondent considered two impacts in mathematics competences among learners resulting from the use of plays. Interviews with the key respondents revealed most of the learners developed mathematics competences through use of plays like constructive plays, free play, water play and sand play.

The researcher using observation was able to learners employ math concepts like counting, grouping, adding, and takeaway while using free play. This study coincided with that of Ginsburg, Pappas, and Seo, (2001) who argued that Play, in particular, represents a medium for promoting interest and mathematical thinking in a developmentally-appropriate manner. For instance, they found out that research shows that learners naturally incorporate math concepts during free play, such as Counting, Adding, Taking away, Comparing, and Grouping.

4.4.4 Response on Challenges Faced in adopting use of Plays in Classrooms

Challenges refer to the facts that hinder individuals from attaining their objective. This study therefore sought the opinion of the respondents whether they faced challenges in adopting the use of plays in classrooms and their responses were as presented in figure 4.3.

Figure 4.3: Response to Challenges Faced adopting the use of Plays in Classrooms



Source: **Survey Data, 2019**

Figure 4.3 shows that 64(74.4%) respondents agreed that they faced challenges in adopting the use plays in classrooms and the constituted the highest population of the respondents while those who disagreed constituted the least population of the respondents 22(25.6%).

4.4.5 Challenges Faced in adopting the use plays in Classrooms

The study found it necessary to find out the challenges faced in adopting the use of plays in classrooms. The respondents were therefore asked to give their opinion on the challenges faced in adopting the use of plays in classrooms and their responses were as presented in table 4.13.

Table 4.13: Challenges Faced in adopting the use of plays in Classrooms

Challenges	Frequency	Percentage
Limited time	48	55.8
Limited material	66	76.7
Limited space	62	72.1
High cost of materials	23	26.7

Source: Survey Data, 2019

Table 4.13 shows that majority of the respondents (76.7%) considered limited materials to be the major challenge faced in adopting the use of plays in classrooms for the development of mathematics competences among early learners, followed by 72.1% who considered limited space and those who considered high costs of materials constituted the least population of respondents with 26.7%. The results also reveal that there were also respondents who considered limited time and they constituted 55.8% of the population. The results further reveal that atleast each respondent considered more than two challenges in their responses and this implies that most of the teachers fail to adopt the use of plays in classrooms because of the different challenges they face in adopting them which limits their interactions with the learners during the learning of mathematics.

An interview with the key respondents revealed that majority of the teachers faced challenges in adopting the use plays to develop mathematics competences. One of them said that "*some learners understand better using plays, however some of the teachers face challenges of time,* *enough space to initiate plays in mathematics classrooms and so making them fail to adopt it. This is one of the reasons why some children fail to develop mathematics competences because they fail to have that interaction with the teachers in terms of play."* This finding therefore is consistent with Vygotsky's theory that emphasizes the importance of the social environment in cognitive development as well as culture and people as the most important factors in the development of an individual. He proved that an individual cannot develop without interacting with the environment (Vygotsky, 1978) and plays are crucial in applicability of this theory.

The researcher furthermore was observed that some teachers in two schools divided the learners into groups during play. This was because of the large numbers of they had which made the learners in the last groups miss out on play. There was also limited space to occupy all the learners at the same time.

4.4.6 Pre-test Results for Relationship between Use of Play and Performance in Mathematics

The researcher during the study carried out a pre-test exercise to investigate the relationship between the use of plays and students' performance. The results of the pre-test exercise were run using an independent sample test and the findings were as presented in table 4.14.

Table 4.14: Pre-test Results for Relationship between Use of Play and Performance in Mathematics

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Performance	Equal variances assumed	.111	.740	7.518	84	.000	24.69111	3.28424	18.16003	31.22219
	Equal variances not assumed			7.554	76.845	.000	24.69111	3.26848	18.18253	31.19969

***Source:* Survey Data, 2019**

Table 4.14 shows the results from an independent sample t test that was run to find the relationship between use of plays and students' performance in mathematics. The Levene's test for equality of variances shows that the variance of the performance in mathematics is not significantly different between the students who used plays and those who did not use plays to develop mathematics competences since the p-value 0.740 is greater than the chosen $\alpha = 0.05$.

The t-test for equality of means shows that the mean marks of learners in mathematics is significantly different between the learners' who used plays to develop mathematics competences and those who did not use plays ($t_{7.518}$, $p<0.05$).

The average performance of learners who used plays to develop mathematics competences is higher than the average of learners who did not use plays by 24.69111.

CHAPTER FIVE

DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter covers discussions of the study results in line with the key objectives that guided the study. It provides an interpretation of the findings obtained; it illustrates why the findings are relevant to the research in relation to findings of other researches carried out. The findings of this study are based on the interpretation and analysis of data obtained through the process of questionnaire and focus group discussions. The chapter also presents the conclusions that were derived from the discussion and the recommendations that ensued from the conclusion. Finally, the chapter provides specific areas recommended for further research.

5.2 Discussion

This section presents the discussion of findings as derived from the study, basing on each objective.

5.2.1. Mathematics Manipulative Materials and Development of Mathematics Competences

The study findings established that most of the teachers (98%) considered counting sticks to be the most common manipulative used to teacher learners mathematics competences in their classrooms, followed by 90% who considered bottletops and the least percentage of the respondents (14%) considered measuring cups. The findings also revealed that there were other kinds of manipulatives used to teach learners mathematics competences and they include; number cut outs that constituted 85%, shape cut outs 72%, strings 71%, playing cards 69%, abacus 62%, pattern blocks 38%, geometric blocks 36%, wooden beads 30% and number cubes 22%.

This study confirmed that most schools manipulative materials found in the classrooms were physical. This trend of physical maniplatives have been by several scholar (Margret, 2014) who found out that Froebel in 1937 used physical manipulatives like geometric blocks and pattern activity blocks to teach mathematics in kindergarten.

The study also confirmed that manipulative materials improved on the learner's mathematics competences such critical thinking, counting ability. These competences coincided with that of several scholars (Seefeldt and Wasik, 2006) who mentioned that materials should "foster children's concepts of numbers and operations, patterns, geometry, measurement, data analysis, problem solving, reasoning, connections, and representations.

The study also established that teachers faced challenges in accessing manipulatives, (67.4%) considered high costs of some manipulatives to be the major challenge faced in the accessing manipulative materials in classrooms, followed by 50% who considered scarcity of some manipulatives in market and only 29.1% considered low quality of some manipulatives which affected teaching of mathematics competences to the early learners. The results further revealed that there were also those who considered limited storage facilities of materials in classrooms and they constituted 45.3% of the respondents. The results imply that early failure to develop mathematics competences was because of the challenges faced by their teachers in accessing manipulative materials that could easy their ability to develop the competences through practical engagement in the learning process.

These findings therefore contradicts those of Anderson, J., Reder, L., and Simon, H. (2000), who mentioned that many different manipulatives are commercially available, and it is also possible to make them using common objects, such as craft sticks, beans, or buttons. They also contradict Cope, (2015) who argued that physical manipulatives range from low-cost, simple, everyday items, such as buttons, paper clips, tooth picks, dominoes, money, string, playing cards, rulers, number cubes, graph paper, empty egg cartons, measuring cups, and film canisters to more complex and discipline-specific items, such as calculators, two-color counters, thermometers, decimal tiles, pattern blocks, Cuisenaire rods, geo-boards, tangrams, algebra tiles, and pantomimes

Furthermore, the results of study established that most teachers used the manipulative materials to teach mathematics competences to the learners during the daily mathematics lessons. This trend was controverting with that other scholars (Moyer 2001) who found out that Indonesian teachers usually use manipulatives just if they have extra time. However, it coincides with the theories of learning by Piaget, Brunner, and Ausubel that suggest that it is important to present concrete objects in mathematics learning such that the learning becomes meaningful, and therefore, the students could easily understand the concepts and are not easily forgotten (Furner and Worrell, 2017; Cockett and Kilgour, 2015; Larbi and Mavis, 2016).

5.2.2. Use of Concrete–Representational-Abstract (CRA) Model and Development of Mathematics Competences

The study findings on this objective established that 43.8% considered using the model when introducing new concepts and they constituted the highest population of the respondents, followed by those who considered when encountering difficult mathematics problems and they constituted 33.3% of the respondents and only 22.9% considered during mathematics lessons.

This showed that learners were taught the mathematics competence using CRA model sequences were able to develop their representation, and construct mathematics concepts.

These findings were in line with the argument of Witzel, (2005) that the use of manipulatives increases the number of sensory inputs a student uses while learning the new concept, which improves the chances for a student to remember the procedural steps, needed to solve the problem. The findings were also consistent with that of (Miller, Stringfellow, and Kaffar, 2011) who found that students made their own representations of the operation and internalize the meaning of these representations and relations to other operations.

The study further established that the CRA model benefited that the learners with learning disability more as they were able to construct and represent mathematics concepts as a result of using this approach of teaching. These study findings therefore coincided with the arguments of Anstrom, (2012) who mentioned that using the CRA approach is very effective for students who have a learning disability in math.

The study furthermore revealed that the average performance of learners who used the CRA model in learning the mathematics concepts were higher than for those who used the model only during difficult mathematics concepts. This finding was consistent with that of Miller and Mercer (1993) used CRA to teach fifth grade students who struggled in mathematics and they found out that students (n = 52) receiving CRA instruction in multiplication improved from scores of 43% to 91%. Students (n = 19) receiving CRA instruction in division improved from scores of 9% to 81%.

5.2.3 Use of Play and Development of Mathematics Competences

It was noted that, in Kira municipality the most used type of plays were: physical play, creative play, and pretend play in developing mathematics competences. This reveals that learners develop a number of mathematics competences during play such as counting, additive, subtraction and even communicating mathematics. Furthermore the method also help learners to solve the daily mathematics challenges encountered in the day to day life like getting change during purchase of commodities. In order to concretise these findings, one of findings revealed that physical is the most common type of play in very young children (Montague-Smith and Price, 2012) as it involves bodily movements such as clapping, hopping and jumping.

The study also established that plays improved on the learners' ability of thinking, counting addition and subtraction. This trend was confirmed by several studies (Ginsburg, Pappas, and Seo, 2001) in which it was argued that play, in particular, represents a medium of promoting interest and mathematical thinking in a developmentally appropriate manner. For instance, they found out that research shows that learners naturally incorporate math concepts during free play, such as Counting, Adding, Taking away, Comparing, and Grouping. A study in the Netherlands found that 6th grade students who spent more free time in construction play performed better on a test of mathematics word problems (Oostermejier et al 2014). There are also several studies found play to be effective in the acquisition of mathematical competencies (Gasteiger 2015; Jörns et al. 2014; Kamii and Kato 2005; Ramani and Siegler 2008; Schuler 2013).

The study furthermore established that there were challenges of time, space, materials and cost of materials faced in using play to develop mathematics competences. This was confirmed by several studies (Bergen 2015) who argued that it needs to be recognised that role-play, or pretend play, requires much time for the children to set up the play-frame, to engage with the play and develop it. Another research indicated that children do not always engage in mathematical learning opportunities as play can often be restricted by such contextual factors as lack of resources, curriculum overload, limited space, and class or group size (Kernan, 2007; McGrath, 2010). Children's dispositions, arising from their experiences, might also be implicated here (Dunphy, 2006), and some children may need encouragement and support to engage in a mathematical way in play, or in mathematical play. Furthermore, another limiting factor may be the undervaluing of the potential of play by adults, who may be under pressure to provide evidence of specific types of learning (Wood and Attfield, 2005).

5.3 Conclusions

This study came up with the following conclusions on the kinds of manuplaitives, Concrete–Representational-Abstract (CRA) Model and types of play in constructive pedagogy

5.3.1. Manipulative Materials and Development of Mathematics Competences

This objective sought to assess the different mathematics manipulative materials used and their effectiveness in the teaching of mathematics competences. The study reveals the following conclusions in line with the findings.

Foremost, the study established that counting sticks and bottle tops were the most commonly used manipulatives in the teaching of mathematics competences in Ugandan classrooms for early learners. Moreover, more than 90% of the respondents confirmed that mathematics manipulative materials were instrumental in the development of mathematics competences among the early learners. Additionally, the key respondents affirmed that mathematics manipulative materials were very effective in developing mathematics processes and facilitated better understanding of the children. Based on these findings, we can conclude that first; any sound lesson on any mathematical topic should involve multiple instructional methods that mathematics manipulative materials should not only be used when teachers have extra time.

Secondly, it is worth noting that using a variety of approaches to constructivist pedagogy and the use of manipulatives increases the possibility that all students will develop mathematical competences through at least one method. Lastly, when manipulatives are used and children placed at the Centre of the learning process (child-centered approach), the role of the teacher changes from transmitter of knowledge to being a facilitator of learners' discovery. This leads to better skills development. Individual children have different ways of learning and when manipulatives are used in the teaching of mathematics competences among pre-primary children, their senses are brought into learning, leading to better acquisition of the said skills.

5.3.2. Concrete–Representational-Abstract (CRA) Model and Development of Mathematics Competences

In the objective of finding out the Use of Concrete–Representational-Abstract (CRA) Model, it was concluded that The CRA model facilitated learners to construct their own understanding of concepts without it learners receive little knowledge if any.

The found out that the CRA model improved on the mathematics competences of children with learning disabilities which coincided with the argument of several scholars (Anstrom, 2012) who mentioned that using the CRA approach is very effective for students who have a learning disability in math.

The CRA was also found to improve on learners' representation and the trend was consistent with other findings (Miller, Stringfellow, and Kaffar, 2011) who found that learners made their own representations of the operation and internalized the meaning of those representations and made relations to other operations. Based on such findings the researcher therefore concluded that the use CRA model in teaching mathematics helps learners to develop mathematics such as concept construction, and representation which thus improves on their performances.

The study furthermore concluded that the model is more effective if used in sequential manner that is to say following the steps from concrete to representation to abstract.

5.3.3 Play and Development of Mathematics Competences

In the first instance, play way method, physical play was the most commonly used play to develop mathematics competences. The most commonly used physical plays among learners included free play and guided play to develop the mathematics competences. The study concludes that the use of play promoted interest and mathematical thinking in an appropriate manner.

Furthermore it was also concluded that play enables learners naturally to incorporate math concepts during free play, such as Counting, Adding, Taking away, Comparing, and Grouping

It is also worth noting that using a variety of approaches to constructivist pedagogy and the use of manipulatives increases the possibility that all learners may develop mathematical competences through at least one method. When manipulatives are used and children placed at the centre of the learning process (child-centred approach), the role of the teacher changes from transmitter of knowledge to being a facilitator of learners' discovery. This leads to better skills development. It is therefore important that learning of concepts like Mathematics competences be hinged on the use of a variety of manipulatives in order to captivate the different learners with their varying learning needs and abilities. Besides, it is important that approaches that place the children at the centre of their learning should be fully embraced for better acquisition of mathematics competences.

5.3.4. Conclusion on mathematics competences development

These research findings indicate that playful learning experiences foster children's early mathematical thinking and reasoning. Children's interest is picked through active, engaging experiences that facilitate mathematical 'meaning-making' and conceptual understanding. The data suggests that if we want to groom children who are more interested in math, more motivated to learn, have the ability to see relations in the world around them and who can better reason symbolically about those relations, playful learning might provide an optimal pedagogy. The study justifies the use of communication in form of reading, interpreting and sharing mathematical information to children to learn and internalize information required for the development of their competencies. In the current Ugandan education system, the study also concluded that in order to strengthen mathematics skills there is need to enforce the use of symbolic, formal and technical language so as to improve the understanding, manipulating, and making use of symbolic expressions to enable children develop their mathematics skills in their earlier years. The study further concluded that reasoning and argument are some of the logical steps and thought processes for children enabling them to explore and link problem elements to make inferences from them and to provide a justification for their mathematics problem solving.

5.4 Recommendations of the Findings

In this study, it was established that use of manipulatives in teaching is effective. It is recommended that school administrators should invest in the use of manipulatives not only by providing the manipulatives but also by empowering teachers and head teachers to strongly use them. This will require providing ample time, materials, and teacher support, so as to create a favourable environment for children to engage in play, a context in which they explore and manipulate mathematical ideas with keen interest.

Equally important is that school administrations should design institutional structures and policies that support teachers' ongoing learning, teamwork, and planning, so as to create a favourable environment for practicing constructivist pedagogy. This will help to motivate teachers and enhance their ability to use the constructivist approach by using manipulatives.

To the Ministry of Education, there is need to create more effective early childhood teacher preparation and continuing professional development. This will help to equip teachers in the use of constructivist pedagogy in teaching and enable them to remain relevant amidst the changing needs and demands in education. Besides, it will also help school administrators to pay more attention to the use of manipulatives in teaching.

On approaches to constructivist pedagogy, the study revealed that the teachers used varied methods, such as playway method, problem-solving method, among others. Relatedly, results indicated a strong inclination towards the use of the child-centred approach to learning, where the teacher is more of a facilitator of the learning process. In this respect therefore, the researcher recommends that school administrators should ensure that teachers actively introduce mathematical concepts, methods, and language through a range of appropriate experiences and teaching strategies. This will require keen observation of the learners and their learning environment.

To the policy makers, it is important that more efforts are invested in monitoring and evaluating the actual teaching process in pre-primary schools. This will help to ensure that standards are conformed to as necessary and that new trajectories in constructive pedagogy are incorporated into the curriculum to effectively improve learning. Equally important is the need for in-service programmes for teacher development, especially on the approaches and methods to teaching among pre-primary children. This is more so against the background that there does is no standardized curriculum for the many institutions involved in training pre-primary teachers.

Lastly, pertaining to development of mathematics competences among pre-primary children, it is recommended that the policy makers at the Ministry and District level should come up with strategies for assessing children's mathematical knowledge, skills and strategies. This will ensure that teachers and schools in general can place the much needed emphasis on mathematics competences development, more so using the constructivist approach of using manipulatives.

5.5. Recommendations for further research

This study was limited to constructivist pedagogy and development of mathematics competences. It was against a background that mathematics forms a strong foundation for many other skills, such as reasoning, problem solving, among others. However, various literatures show that a negative attitude towards mathematics that is normally formed among learners in early childhood could hamper their interest in mathematics and therefore hinder the acquisition and development of the said skills. Future researchers could explore the link between attitude and development of mathematics competences among pre-primary children.

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Appendices

Appendix I: Consent letter

Kyambogo University

P.O. BOX 1, Kyambogo

Kampala, Uganda

25/05/2018

Dear Sir/Madam,

RE: SEEKING FOR YOUR CONSENT IN THIS RESEARCH STUDY

You have been randomly selected to participate in this survey leading to the award of a Master of Education in Early Childhood Development Degree of Kyambogo University. As a person involved in activities regarding education of children especially ECD, you are so resourceful in providing relevant information for this study. The topic of study is **Constructivist Pedagogy and the development of mathematics Competences in Pre-Schools in Kira Municipality, Wakiso District".** Therefore, you are being contacted to participate in this study through interviews/Focus group discussions regarding the above topics.

With this letter, I am asking for your consent to participate in the study. This is an academic study. Hence your responses will be used for academic purposes and treated with utmost confidentiality.

Yours faithfully,

....

GRACE GLORIA KEMBUBI

Student/Researcher Kyambogo University

Appendix II: Classroom Observation guide

Observation guide for the Researcher

Name of the school..........................Zone.........................Date..................Time......................

1. Kinds of manipulatives being used in classrooms
2. Learners ability to interpret mathematics signs in from the use of different kinds of manipulatives
3. Challenges faced in utilizing different kinds of manipulative materials in classrooms during lesson hours.
4. Applicability of the Concrete-Representation-Abstract model in class
5. Learners involvement in the application of Concrete-Representation-Abstract model
6. The different types of constructive plays used in the schools
7. Learners' involvement in the use of constructive plays
8. Learners' ability to make mathematical relate plays and mathematical concepts
9. Challenges faced by different learners in using different plays to relate mathematics concepts

Appendix III: Questionnaire for Teachers

This questionnaire is for purposes of collecting information relating Constructivist Pedagogy and the Development of Mathematics Competences in Pre-Schools in Kira Municipality, in pre-schools. All information will be used for the purpose of the study only and will be treated with utmost confidence. Kindly respond to all questions as possible. Your cooperation will be highly appreciated.

Section A: Mathematics Manipulative Materials and Mathematics Competences

1. What mathematics manipulative materials do you use in your classrooms to develop mathematics Competences amongst the early learners?

   1) ....
   2) ....
   3) ....
   4) ....
   5) ....
   6) ....
   7) ……………………………………………………………………………………..
   8) ………………………………………………………………………………………

2. How do the manipulative materials you use influence the learners' competences in mathematics

   ____

   ____

3. Do you face challenges in accessing the different mathematics manipulative materials in classrooms? Tick in the box an appropriate option.

   a) Yes ☐

   b) No ☐

4. If yes, what challenges do you face in accessing the different manipulative materials in classrooms? List them in the space provided below.

5. How often do you use the manipulatives in teaching of mathematics competences to the early learners? Tick in the box for an appropriate option.

a) When introducing new concepts ☐

b) During the mathematics lessons ☐

c) When handling difficult math problems ☐

d) When you have extra time ☐

Section B: Concrete-Representation-Abstract and Mathematics Competences

6. Do you apply the concrete-Representation -Abstract model in your classrooms to develop mathematics competences among the early learners? Tick in the box to indicate your option.

   a) Yes ☐

b) No

7. If yes, how often do you apply the model in your classrooms? Tick the appropriate option.

   a) During the normal mathematics lessons

   b) When introducing new concepts

   c) While encountering difficult mathematics problems

   d) When you have extra time

8. Do you follow the steps in order while applying this approach in classrooms? Tick in the box an appropriate option.

   a) Yes

   b) No

9. How does the approach impact on the mathematics competences among early learners in your school? Provide your answers in the space provided below.

   ____

   ____

   ____

   ____

10. From your own experience, do you think that this benefits some categories of learners more?

    a) Yes (specify) ________________________________

    b) No

Section C: Play and Mathematics Competences

11. Do you use play in your classrooms to develop mathematics competences among early learners? Tick in the box an appropriate option.

    a) Yes

b) No

12. If yes, what types of play do you employ in your classrooms to develop mathematics competences among early learners?

____

____

____

____

13. How does the application of play in classrooms impact on the learners' performance in mathematics?

____

____

____

____

14. From your experience, are there challenges faced while adapting the use of play in classrooms?

a) Yes ☐

b) No ☐

15. If yes, what challenges do you think are majorly faced and how do they affect the learners' ability to develop mathematics competences

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Thank you for your time.

Appendix IV: Interview Guide for Head teachers and Teachers

Dear respondents, I am a student pursuing a Master of Education in Early Childhood Education. I am currently conducting a study on "Constructivist pedagogy and the development of mathematics competences: A case study of selected Pre- Primary Schools in Kira Municipality, Wakiso District". This discussion will take between 40-60 minutes. Everything discussed here will be confidential and solely for this research.

Thank you for your participation

1. What kind of manipulatives do you use to develop mathematics competences among early learners?
2. How often do the teachers use the manipulatives to develop mathematics competences among learners?
3. How do the manipulatives you use impact on the learners' competences in mathematics?
4. Do you face challenges in adopting the use of different kinds of manipulative materials in classrooms?
5. What challenges do you face in adopting the use of different kinds of manipulative materials?
6. Do you apply the Concrete-Representation-Abstract model on your classrooms to develop mathematics competences among early learners?
7. How often do you apply the model in your classrooms?
8. Do you follow the necessary steps while applying this model in classrooms?
9. How does the model impact on the mathematics competences among learners?
10. Do you think that this model benefits some categories of learners more?

11. Do you use constructive plays in classrooms to develop mathematics competences among early learners?
12. What type of constructive plays do you apply in classrooms to develop mathematics competences?
13. Could you be facing some challenges in adopting the use of constructive plays in classrooms?
14. What challenges do you think are majorly faced and how do they affect the development of mathematics competences among learners