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Influence of Problem Solving Approach on Secondary School Students' Mathematics Self-Concept in Commercial Arithmetics in Kenya

Mutange Ronald Ellumbe

Department of Science and Mathematics Education, Masinde Muliro University of Science and Technology, P.O. Box 190-50100, Kakamega, Kenya

Abstract: **In Kenya, the fundamental challenge facing learning of mathematics in secondary schools is how to enhance students' affective characteristics associated with the teaching/learning process. Based on this challenge, the present study investigated the influence of using Problem Solving Approach on secondary school students' mathematics self-concept in Commercial Arithmetics in Kenya. The purpose of this study was to determine whether the use of Problem Solving Approach has any influence on students' mathematics self-concept. Students from one hundred and nine schools from Vihiga County formed the population of the study. Stratified random sampling was used to select twelve schools from the 109 schools. A total of 1459 Form Three students were selected from the twelve schools that participated in the study. The respondents were from national, county and district schools. The Solomon Four-Group design was used in the study. The respondents were assigned in their intact classes to experimental groups 1 and 3, and control groups 2 and 4. All the groups were taught the same content of the topic Commercial Arithmetics. However, groups 1 and 3 were taught using Problem Solving Approach while groups 2 and 4 were taught by conventional methods. Groups 1 and 2 were pre-tested prior to the implementation of the Problem Solving Approach treatment. Mathematics Self-Concept Questionnaire was used to collect data. The instrument's validity was determined by the researcher, a panel of mathematics educators from the Department of Science and Mathematics Education at Masinde Muliro University of Science and Technology and experienced secondary school mathematics teachers. A Reliability coefficient of 0.739 was obtained for Mathematics Self-Concept Questionnaire using Cronbach's Coefficient alpha formula.**

After the treatment, all the four groups were post-tested. Significance of differences between the means of the experimental and control groups on the variables of pre-test and post-test were measured by the t-test and Analysis of Variance. The results show that improved students' mathematics self-concept occurred among students where Problem Solving Approach was used. The researcher concluded that Problem Solving Approach is an effective teaching approach. It was helpful in enhancing the teaching and learning of mathematics, facilitated in making the subject easily understandable to students and improved their mathematics self-concept and consequently their achievement in the subject. Therefore, mathematics educators should encourage mathematics teachers to use it and teacher educators to make it part of the teacher-training curriculum.

Keywords: **Problem Solving Approach, Secondary School, Students' Mathematics Self-Concept, Kenya.**

1. INTRODUCTION

Mathematics is one of the core subjects in the Kenya secondary school curriculum. It is an examinable subject for all students (Kenya Institute of Curriculum Development [KICD], 2006). Much importance is currently attached to it by the society. As a tool, it finds its application in daily lives at home, in the office and in scientific and technological fields. Despite its importance, students have consistently performed poorly in the subject. This is evident from the Kenya Certificate of Secondary Education (KCSE) examination results. The years 2006, 2007, 2008 and 2009 recorded low mean scores of 38.08, 39.46, 42.59 and 42.26 respectively (KNEC, 2010). The mean score figures indicate that there was a slight decline in the overall mean score in the year 2009 compared to the previous year. However, the general performance in the subject is poor as depicted by the low mean scores. This poor performance was attributed to poor teaching and/or learning strategies (KNEC, 2007-2009).

In the recent past, teaching and learning practices have undergone changes of revolutionary proportions; changes underpinned by shifts in psychological and pedagogical theory in teaching and learning process. The new developments advocates for new approaches to mathematics teaching and learning, not only in secondary schools but also in teacher education (Okigbo & Osuafor, 2008). Research findings on learning and memory show that for learning to be effective, the learner should be actively involved in the learning process (Lambros, 2002). Piaget believed that there is no true learning unless the students mentally act on information and in the process, assimilate or accommodate what they encounter in their environment (Trowbridge & Bybee, 2004). Unless this assimilation occurs, teachers and students are involved in pseudo-learning, which is knowledge retained only for short time. Efforts made to translate these new conceptions of learning into classroom practices include development of instructional methods that engage the learner actively in the process of knowledge acquisition. Mathematical problem solving is a teaching approach that is learner-centred. It may improve and motivate students' learning, problem solving skills and broad mathematics knowledge, based on deep understanding and problem solving (Major *et al.*, 2000)

Cognitive psychology research has provided considerable insight into the way the learners acquire and organize knowledge. A growing body of research today points to active learning strategies in which the students listen, talk, write, read and reflect as they become directly involved in the instructional process (Roh, 2003). Constructivist theories of learning which had its roots from cognitive psychology place the learner in an active role of knowledge construction. The learner approaches a domain with some prior knowledge about the subject matter constructed from personal experiences, schooling, and social interactions (Okere, 1996). Concepts change as the learner attempts to connect new information with existing conceptual framework. According to constructivist theories of learning, conceptual change in learners should be facilitated by problem solving activities such as having students actively engaged in processing knowledge; confronting their conceptual framework; confronting defending alternatives perspective; linking new concepts to old; and using strategies that encourages both meta-cognition and higher order thinking (Walker & Lofton, 2003).

Effective strategies designed to promote efficient and meaningful learning rely upon connecting prior knowledge to new concepts (Cook, 2001; Okerere, 2006). The importance of meaningful learning in promoting conceptual understanding that in turn facilitates problem solving was stressed by Bransford and Stein (1984), Eylon and Linn (1988) and Mangle (2008). Research in different areas in mathematics and in other subjects has established the existence of positive relationships between students' meaningful learning approaches and their achievement in mathematics (Wentzel, 2002; Boaler, 2002; Samuelsson, 2008). According to Ramsden (1995) meaningful learners have a deep approach to learning. They tend to build a holistic description of content, reorganise new content by relating it to prior knowledge and/or to personal experiences, are inclined to use evidence, and maintain a critical and a more objective view. Conversely, rote learners have a surface approach to learning; they have a propensity for memorisation of mathematics facts, concepts, principles and strategies and are motivated extrinsically by fear of failure rather than the need to learn and understand.

Students' learning difficulties can often be attributed to ineffective or inappropriate cognitive processes (Herreid, 2003). Earlier, Ramsden (1995) contended that approaches to learning are associated with learning outcomes. According to Novak and Gowin, meaningful learning occurs when individuals choose to relate new knowledge to relevant concepts and propositions they already know (Novak & Gowin, 1984). This calls for commitment on the part of the learner to link new concepts with higher order and more inclusive concepts that are already understood by the learner that can serve to anchor new learning and assimilate new ideas (Novak, 1998). The commitment aspect calls for interest and general positive attitudes toward the learning process as well as the subject being studied by the student. This is why research in mathematics education stresses the need of fostering affective relationships in mathematics instructions (Hemke, 1990; Pajeres & Schunk, 2000; Watt, 2004). Affective characteristics thus form a base upon which meaningful learning can be promoted.

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The persistently low enrollment in mathematics-oriented courses particularly in tertiary institutions have aroused concern of mathematics educators, researchers and policy makers the world over (Changeiywo, 2001; Githua, 2002). As a result most countries are seeking to improve their mathematics education standards by promoting programs that not only enhances effective acquisition of rapidly growing bodies of mathematics knowledge in a well organized framework, but also promotes the learners' capability to learn mathematics meaningfully (Novak, 1998). In practice, while the preponderance of scientific effort swirls around experimental achievements, conceptual achievements continue to be astoundingly important in the overall advancement of mathematics (Wagner & Benavente-McEnery, 2006). If mathematics education aims at preparing students who can think logically and conceptually; solve traditional as well as novel mathematics problems; work efficiently with confidence and accuracy; use meaningful problem solving strategies and are committed to pursuing the study of mathematics; then the focus should be on teaching for understanding rather than students memorising mathematics facts, skills, concepts, principles and strategies (Cooper & Robinson, 2000).

Many students in Kenya perform poorly in mathematics. The poor performance is mainly attributed to poor teaching and learning strategies. It is this poor performance that prompted the Government of Kenya through the Ministry of Education, with assistance of the Government of Japan through Japan International Co-operation Agency (JICA), to initiate a program on Strengthening of Mathematics and Science in Secondary School Education (SMASSE, 2003).

The importance of good teaching cannot be overemphasized. Good teaching encourages high quality learning (Ramsden, 1995). According to Mondoh (2000), students' difficulties in solving problems in mathematics may be traced to: poor understanding of the basic concepts, dependence on algorithms, and inability to apply what they knew, among others. The teaching of mathematics is not just about dispensing rules, definitions and algorithms for students to memorize. There is need to engage students as active participants through discussions and collaboration in problem solving among themselves. If students are given the opportunity to explain or clarify mathematical ideas, more meaningful learning results. Lau (2009) alludes that the mathematics skills required for the youth of today and the adults of tomorrow to function in the workplace are distinct from that for the youth and adults of yesterday. In terms of the 21st century pedagogy, the development of education now requires teaching strategies that emphasize students' involvement (Silva, 2009). Much success lies in students being able to communicate, share and use information to solve mathematical problems. According to Johnson and Johnson (1995), to achieve success in learning mathematics, learners should be given the opportunity to communicate mathematically, reason mathematically, and develop self confidence to solve mathematics problems.

Successful mathematics teaching is associated with explicit teaching of a coherent conceptual framework rather than simply involving students in activities and hoping that meaningful learning results. Thus it is important that mathematics teaching focuses on the quality of understanding rather than on the quantity of information presented. Unfocussed or purposeless activity in the classroom leads to little if any learning. Duffy and Jonassen (1992) argue that teachers should develop instructional strategies that engage learners actively in the process of knowledge construction to enable them learn meaningfully. Learning is considered to be an active, constructive, cumulative, self-regulated and goal-oriented process in which the learner plays a critical role (Trowbridge & Bybee, 2004). There is need to develop teaching strategies that conform to this new perception of learning to enhance meaningful learning.

An analysis of the KCSE examination question papers indicates that questions on Commercial Arithmetics keep recurring year after year, yet no marked improvement has been realised in terms of student performance in the topic even as the general performance in mathematics remains poor (KNEC, 2010). This suggests that students have a problem with this topic. The poor performance depicted by students in this topic portrays inadequate understanding of concepts in it. Teachers have been blamed for using inappropriate instructional techniques in teaching this topic. Techniques that promote student-centred learning are seldom used. This is due to poor instructional approaches used in teaching mathematics (Mondoh & Yadav, 1998; Githua, 2001; Changeiywo, 2001; KNEC, 2010). It is however important that students perform well in this topic since Commercial Arithmetics gives useful information applied in daily life at home, in accounts and in commerce (KICD, 2001).

Studies conducted in America found a link between self-concept and achievement in mathematics (Pajeres & Schunk, 2000; Watt, 2001). Marsh (1990) found that mathematics achievement is highly correlated to mathematics self-concept. In an earlier study carried out on fifth and sixth grade pupils in Australia, Marsh *et al.* (1984) found that girls had a significant higher mean score in reading self-concept than boys. They also found out that difference in pupils' mathematics self-concept by grade level as demonstrated by mean scores was significant and that their mathematics self-concept consistently dropped with increasing class levels. Ng'eno (2005) found that pupils' mathematics self-concept consistently increased with increasing class level to reach the highest level in class eight. In Kenya, studies done reported contrasting results as concerns learners' mathematics self-concept. At the secondary school level, Githua (2002) reported a decline in students' mathematics self-concept between Form one and Form three where it recovers slightly due to the expectation of the national examination. This implies that any intervention programmes designated to enhance students' mathematics self-concept will positively affect their learning and consequently their achievement in mathematics. This study investigated the influence of using PSA on students' mathematics achievement and self-concept.

In Kenya, previous studies on performance in mathematics education concentrated on the direct effects of students' background factors and school environment, students' attitudes and type of instruction (Kirembu, 1991; Makau & Coombe, 1994). Mondoh (1995) identified teaching effectiveness, which is influenced by the teaching approach, as the most significant variable in mathematics achievement.

Problem Solving Approach (PSA) has been widely accepted as the way to teach vocational agriculture. On effects of level of PSA to teaching on students' achievement and retention, Boone (1990) found that students' level of achievement and retention was highest when PSA to teach was used. In the same study, Boone found that for high level cognitive items, students taught by PSA exhibited lower achievement loss than those taught by subject matter approach. In an earlier study, Boone (1988) found that high school agriculture students taught using PSA first in an instructional series had higher achievement scores than those taught first using a subject matter approach. Consequently to achieve effective learning and good performance in mathematics, the topic of Commercial Arithmetics need to be taught using student-centred approach. Zechariah (2010) contends that instructional methods employed by the teacher play a significant role in the acquisition of skills and meaningful learning. Instructional methods such as lecture make students become passive and have less interaction with each other in doing tasks. Changeiywo (2001) asserts that the lecture method adopted in schools makes students to be isolated from one another, leading to low self-concept and a high failure rate in sciences and mathematics. Changeiywo is of the view that positive changes take place when a teacher changes the teaching method toward a more student-centred approach. Consequently, an alternative method for the delivery of mathematics knowledge is PSA.

According to Mangle (2008), PSA involves students working in small groups to achieve a common goal, under conditions of positive interdependence, individual accountability, appropriate use of collaborative skills and face-to-face interactions. PSA is the instructional use of small groups through which students work together to maximize their own and each others' learning. Problem solving has its foundation in social-constructivist perspectives of learning. In this approach, the classroom environment is characterized by co-operative tasks and incentives structures and by small group activities. It can be used to teach 'hard' topics in mathematics and also help teachers to accomplish important social learning and human relations goals. Mangle provides benefits on the use of the PSA on students' achievement in mathematics as: students achieve higher grades; develop positive attitude towards mathematics; positive self- concept and their social skills are enhanced. PSA also promotes deep learning of materials and help students to achieve better results in mathematics.

PSA has been shown to lead to improved achievement in mathematics to senior students and those in colleges. Samuelsson (2008) found that PSA teaching approach is more effective than the conventional methods in the academic success of students and it enhances their mathematics self-concept. Segzin (2009) reported that in PSA sessions, students tend to enjoy mathematics, and this enjoyment motivates them to learn. Several researches on PSA have been on senior students and those in colleges in the Western environment. Hence, it was less clear whether PSA could be successfully applied to secondary school students in other countries in which social, religious, educational, and cultural practices are different from those of the Western countries. It is against this background that the current study investigated the influence of PSA on students' mathematics achievement and self-concept in Commercial Arithmetics in Kenya.

From the foregoing, none of the studies so far sought to find out how PSA influences students' affective characteristics with an aim of promoting meaningful learning. In an attempt to fill this gap, the current study investigated the influence of

PSA on secondary school students' mathematics self-concept in Commercial Arithmetics in secondary schools in Vihiga County.

Purpose of the Study:

The purpose of this study was to investigate the influence of Problem Solving Approach (PSA) on secondary school students' mathematics self-concept in Commercial Arithmetics compared to traditional mathematics teaching approach.

Objective of the Study:

The objective of the study was to determine the influence PSA has on students' mathematics self-concept as compared to conventional methods.

Hypotheses of the Study:

The following null hypothesis was tested at an alpha level of 0.05:

HO_1: There is no significant difference between the mathematics self-concept of students who learn using PSA and those taught using conventional methods.

2. LITERATURE REVIEW

Self-concept is the set of cognitions and feelings that one has on oneself (Marsh, 1990). According to Byrne (1984), self-concept refers to attitudes, feelings and knowledge about our abilities, skills, appearance and social acceptability. It is the total organization of the perceptions individuals have of themselves (Dembo, 1994). It influences individuals place on self and their behaviour. Self-esteem is a result of being competent at valued tasks and reinforcement from others (Biehler & Snowman, 1997). To arrive at a general perception of self, individual collects information on which to base his/her perception in order to form his/her self-concept which is organized (Dembo, 1994).

Individuals change their self-concept with change in cognitive development, social situations, interactions with parents, peers, teachers and institutions such as home and schools. Self-concept is evaluative in that individuals evaluate themselves in given situations. For example, within a mathematics classroom a student may have a low self-esteem but could surprisingly have very high self-esteem during Geography lessons. Marsh (1990) indicated that the criterion of self-evaluation or frame of reference is important in the formation of self-concept.

According to Fredrick and Eccles (2002), self-concept development in males and females can be explained by gender intensification theory and gender convergence theory. Gender intensification theory suggests that gender-role activities become more important to young adolescence overtime as they try to conform more to gender-role stereotypes. Females become more negative about male-stereotyped domains, such as mathematics while males become negative about female-stereotyped domains, such as arts. On the contrary, gender convergence theory proposes the opposite development in gender differences in self-concept. Proponents of this perspective argue that boys begin school with higher and unrealistic expectations. However, they adjust these expectations over the school years in response to performance feedback and the increased salience of social comparison processes. According to this view, the gender gap in self-concept decreases because girls do not initially overestimate their capabilities to the same extent as boys, meaning that the negative change in girls is smaller or even absent.

Self-concept is a multi-faceted construct. Each facet of self-concept has a distinct, stable and measurable domain-specific self-concept construct. According to Marsh (1990), mathematics self-concept is one of the academic facets of self-concept. Mathematics self-concept is the learners' self-perception of their perceived personal mathematical skills, ability, mathematical reasoning ability, enjoyment and interest in mathematics. Learners' perception of their ability in an academic subject is a critical goal in itself and a means of facilitating the attainment of other desirable outcomes, such as academic achievement. There is growing evidence that personal expectations influence achievement behaviours. Schunk and Pajares (2000) argue that when self-beliefs correspond to the academic outcome with which they are compared, prediction is enhanced and relationship between self-efficacy and academic performance is positive and strong. Academic self-concept has been found to be a stronger predictor of achievement than vice versa (Marsh *et al.*, 2005; Trautwein *et al.*, 2006). Males having high self-concept in mathematics perform better in the subject. Females with higher self-competence perceptions in languages and the arts make them perform well in them (Marsh & Yeung, 1998).

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Early studies in the 1980s and 1990s found that academic self-concept declines across middle childhood and early adolescence (Alexander & Entiwisle, 1988; Wigfield *et al.*, 1997). However, the studies also showed that the pattern of decline varies across academic domains, with the sharpest drop in mathematics (Eccles & Medley, 1989). Fredrick and Eccles (2002) and Jacobs *et al.*, (2002) found a decreasing trend for students in grades one to twelve. Initial differences in mathematics in favour of boys declined overtime. On the contrary, Watt (2004) found that gender differences in mathematics self-concept in favour of boys remained stable from grades seven to eleven.

In Kenya, the change in pupils' mathematics self-concept was found to be gradual between classes six and seven, but there was a sharp positive change between classes seven and eight. This is due to the expectations of national examinations. The desire to perform well in examinations makes the learners to have a positive self-worth (Ng'eno, 2005). Moreover, N'geno found a significant difference by age in pupils' mathematics self-concept. The higher mathematics' self-concept for girls is attributed to the fact that they mature early than the boys in primary schools. This can be used to improve their achievement in mathematics. At the secondary school level, Githua (2002) reported a decline in students' mathematics self-concept between Form one and Form three where it recovers slightly due to the expectation of the national examination.

According to de Vries *et al.* (1989), students who experienced Problem Based Learning (PBL) method, herein referred to as the PSA, developed a more positive attitude towards the instructional environment. They also enjoyed the whole learning process better when compared to the once taught with conventional methods. Moreover, Kaufman and Mann (1997) found that medical students taught with PBL program had more positive attitude towards learning in comparison to the ones in the conventional program. Diggs (1997) and Akinoghi and Tandogan (2007) agree that the PBL method has a very constructive influence on science students' opinions about science studies and that this practice allows them to grasp science better. In another study, Canturk-Gunhan and Baser (2008) aver that PBL method affects students' feelings about mathematics in a positive way, and that it improves their academic success and learning of the related concepts. According to a study done in Sweden by Samuelsson (2008), PSA is more effective in developing students' interest and enjoyment of mathematics than the conventional approach. In view of the foregoing literature review, it is apparent that majority of the studies focused on students' attitude toward the instructional environment. None of the studies focused on the influence of PSA to student's mathematics self-concept, warranting the current study.

3. RESEARCH METHODOLOGY

Research Design:

The present study adopted Solomon's Four Group Design that employed the quasi-experimental procedures. This is because secondary schools classes once constituted exist as intact groups and school authorities do not allow such classes to be broken up and re-constituted for research purposes (Gall, Borg & Gall, 1996). Thus it was not possible to assign individual students randomly to groups as required in true experimental designs. The schools selected were however randomly assigned to the treatment and control conditions as intact groups. The pre-test – post-test approach was used to partially eliminate the initial differences between the experimental and control groups (Gibbon & Herman, 1997). The design is considered rigorous enough for experimental and quasi-experimental studies. This is because it provides effective and efficient tools for determining cause and effect relationship. It also provides adequate control of other variables that may contaminate the validity of the study (Borg & Gall, 1989). The design helped to achieve four main intentions, namely: to assess the effect of the experimental treatment relative to the control condition; to assess the interaction between pre-test and treatment condition; to assess the effect of the pre-test relative to no pre-test and to assess the homogeneity of the groups before administration of the treatment (Borg & Gall, 1989).

According to Sharma (2002), the Solomon's Four Group Design is a particular strong quasi-experimental procedure. However, it is important that there is opportunity for both a pre-test and post-test in both the treatment and the control groups. The Solomon Four Group Design that employs the Quasi-experimental research design procedures controls for all major threats to internal validity except those associated with interaction of: selection and history; selection and maturation; and selection and instrumentation (Gibbon & Herman, 1997).

In this study, no major event was observed in any of the sample schools that would have introduced interaction between selection and history. However, to control for interaction between selection and maturation, the schools were randomly

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assigned to the control and treatment groups. The conditions under which the instruments were administered were also kept as similar as possible across the schools to control for interaction between selection and instrumentation (Sharma, 2002). An instructional manual for teachers was developed based on Kenya Institute of Curriculum Development (KICD) approved mathematics syllabus (2002). The manual was used by teachers teaching the experimental groups to ensure that there was uniformity in exposure of students to intervention. Furthermore, all the teachers involved in the study adopted the same schemes of work and similar sequence in covering the content on Commercial Arithmetics in all the schools involved in the study. Hence, there was reasonable control of the threats to internal validity of the study. The design is shown in Table 1

Table 1: Solomon's Four Group Design

Groups	Pre-test	Treatment	Post-test
1	O_1	X (Problem Solving Approach)	O_2
2	O_3	C (Conventional Methods)	O_4
3		X (Problem Solving Approach)	O_5
4		C (Conventional methods)	O_6

Source: Adapted from Gibbon and Herman (1997)

In this design, subjects were assigned randomly to four groups. Groups 1 and 3 received the experimental treatment (X) that was the use of the Problem Solving Approach (PSA) in teaching. Group 1 received a pre-test (O_1) and group 2 received a pre-test (O_3). Groups 2 and 4 constituted the control and use of conventional methods in teaching. Finally all the four groups received post-test (O_2, O_4, O_5 & O_6). The research design is a combination of two group designs, the post-test only and the pre-test - post-test which control extraneous variables of testing, history and maturation (Gibbon & Herman, 1997). The subsequent section describes the treatment.

Description of the Treatment:

The conventionally-designed mathematics instruction was based upon lessons employing lecture/questioning method to teach the topic of Commercial Arithmetics. The teaching strategy depended upon teacher explanations, discussions and textbooks. The teacher treated the entire class as a unit, wrote notes on the blackboard about the definition of different terminology and solved most of the problems in the topic. After the teacher explanation, the concepts were discussed, recapitulated by the teacher's questions. The direction of communication in the classroom was from the teacher to the student. The teacher was the focal point of the discussion and dispenser of the mathematical knowledge.

In the experimental groups, before the treatment, small groups consisting of five to eight students were formed. Then, the students and the teachers were trained to use the PSA. During the treatment, the students worked in small groups and dealt with ill-structured problems. Every member of the group had some responsibilities. Students participated actively in the group discussions. They had to share their knowledge, express their ideas and experiences with each other while searching a solution to the problem. Each of them had to be sensitive to the needs and feelings of the other group members. Apart from the group work, each student had to conduct an independent study and be able to represent, communicate and evaluate his/her learning at both individual and group levels.

During the PSA sessions, the teacher organised the groups and created a purposeful and co-operative atmosphere. The teacher ensured that students had control of the discussion. When guidance was needed, the teacher asked open-ended, very general questions and gave ample opportunity to students to the focus on the goal. The teacher encouraged critical thinking. At the end of the PSA implementation, the students evaluated each other with respect to participation, preparation, interpersonal skills and contribution to group progress. In this way, it was expected that students would become aware of the role expected from them both individually and as a group. The experiment lasted for three weeks. After the three weeks of treatment, post-tests were administered.

Study Location:

The present study was carried out in Vihiga County that lies between longitude 34^o 30' and 35^o 0' east and between latitude 0^o and 0^o 15' north. The equator cuts across its southern tip. It covers a total area of 563 square kilometres. It

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borders the counties: Kakamega to the north, Nandi to the east, Kisumu to the south, Siaya to the south-west and Busia to the north-west (Vihiga District Development Plan, 2002-2008, 2000). The county has two rainy seasons. The long rains fall between February and July, with the peak in April. Short rains fall from September to October. The county has mean annual temperatures ranging between 20°C and 30°C. It is one of the most densely populated counties in the country (Republic of Kenya, 2001). High population density is associated with certain social and economic problems such as unemployment and social conflicts among others. These problems have continued to impact negatively on the educational standards in the county. This indicates that more academic effort is needed in the county to counteract these problems. Thus, it is prudent that the residents of this county be equipped with the knowledge of Commercial Arithmetics. Also, problems involving small scale money transaction can be solved by knowledge of Commercial Arithmetics. The county has been selected because students' achievement in mathematics is poor. For example, the years 2005, 2006, 2007, 2008 and 2009 recorded low mean scores in mathematics of 3.174, 3.026, 3.311, 3.402 and 3.513 respectively, as compared to the maximum aggregate score of twelve points (Education Office Vihiga [EOV], 2010). The inhabitants of this county mainly depend on maize and beans as their staple food. They also grow and merchandise in coffee, tea, sorghum, millet, potatoes and cassava. This forms their economic mainstay. Knowledge of Commercial Arithmetics in school and in daily life activities is thus important for the residents of Vihiga County.

Target Population:

The target population of the current study consisted of all Form three mathematics students from public schools in Vihiga County. The county was chosen for this study because there was no study on the influence of the teaching strategy on students' affective characteristics. This has been blamed on the teaching strategies and to some extend on low mathematics self-concept held by secondary school students in the county; a claim that lacked empirical evidence to support it. Nonetheless, a good teaching strategy encourages high quality students learning (Ramsden, 1995). Thus there was need to explore for innovative teaching strategies that will help promote affective characteristics of the learners if the low self-concept are to be reversed.

Form Three students were chosen because the topic Commercial Arithmetics selected for the study is taught at this level (Kenya Institute of Curriculum Development [KICD], 2002), they could express their mathematical ideas in written form and also because their mathematics self-concept has been judged at the lowest ebb (Githua, 2002). The county has 114 schools: 2 national schools, 10 county schools, 97 district schools and 5 private schools. National, county and district schools were selected. This is because students' achievement in mathematics is poor in the county (Education Office Vihiga, 2010). There were 109 such schools with a population of 10,555 students.

Sampling Procedure and Sample Size:

The sampling frame consisted of all national, county and district secondary schools in Vihiga County. The first stage was the purposive selection of Vihiga County and the type of school (i.e. national, county and district schools) included in the study sample. Purposive sampling was used to select the two national schools that participated in the study. The remaining schools were stratified into boys' only, girls' only and co-educational schools. Ten schools were then drawn out of the remaining 107 schools. Because of the smaller number of schools to sample from, balloting method was employed. This involved assigning a numeral to each of the 107 schools, placing the numbers in a container and then picking a number at random without replacement. Schools corresponding to the numbers picked and having at least three streams at the Form three level were included in the study sample.

According to Mugenda and Mugenda (2003), at least 30 students per group are required for experimental research. They are of the view that the sample size should be sufficiently large enough to allow accurate interpretation of the results as well as ensuring that the data is manageable. Twelve schools were sampled. One class (each with at least three streams) from each school was included in the study sample. The twelve classes in the twelve schools were assigned to the four groups in the Solomon four-group experimental design. Although it was assumed that the average enrolment was forty students per stream, giving the approximate sample size of the study as 1440 students, the actual sample size that participated was 1663 students. During data coding, it was found that some students had either incomplete data and/or missed some test. This reduced the sample size for data analysis to 1459 students. These subjects were used in their twelve intact classes in the twelve schools that were assigned to experimental groups 1 and 3, with 367 and 360 students respectively; and control groups 2 and 4, with 344 and 388 students respectively.

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Research Instruments:

Mathematics Self-Concept Questionnaire (MSCQ) was used to collect data to meet the objective of the study. It was developed and pilot tested prior to the actual conduct of the study. It was developed by the researcher and used as pre-test and post-test. The questionnaire was given to six University lecturers who gave their comments after studying the items. Language and other noticeable problems were corrected. It was then given to three secondary school mathematics teachers who were also examiners with KNEC. They reviewed the items and made their comments. Their feedback was used to improve the items. The improved questionnaire contained eight structured items that solicited students' feelings about Commercial Arithmetics in mathematics. This instrument had items based on students' attitudes, feelings and knowledge about their mathematical skills, abilities, enjoyment and interest in Commercial Arithmetics as measured on a five-point Likert scale. The items on the scale start with the option of "Strongly Disagree" to "Strongly Agree" and are coded from 1 to 5 for the negative statement and vice versa (see Appendix I). The respondents were required to choose their answers that reflected their views on the statements provided.

Pilot Study:

The data collection instrument was pilot tested on 42 Form three students in Vihiga County that did not participate in the study. The students had similar socio-backgrounds as those that were used in the final study. The pilot study aimed at assessing the appropriateness of the instrument.

Validity of the Instruments:

According to Sharma (2002), validity refers to the degree with which the inferences based on test scores are meaningful, useful and appropriate. MSCQ was assessed for the content and face validity respectively. This was done by two experienced secondary school mathematics teachers, the two academic supervisors and two mathematics educators from the Department of Science and Mathematics Education at Masinde Muliro University of Science and Technology. Each panel member assessed the items in MSCQ for language appropriateness, purposefulness, and appropriateness of the distracters. Their responses were measured on a five-point Likert scale (see Appendix II). They were scored and transcribed into a percentage score. An average score of above 70% for face and content validity implied that the instrument was appropriate. The average of the responses of the face and content validity of the instrument is as shown in Table 2.

Table 2: Summary of Assessment of Instrument Validity by Percentage

Instrument	Type of Validity	Mathematics Teachers	Academic Supervisors	Mathematics Educators	Average Percentage	Conclusion
MSCQ	Face	84	90	88	87.33	Appropriate
	Content	94	92	96	94.00	Appropriate

Reliability of the Instrument:

The reliability of MSCQ was ascertained using test-retest method. The instrument was administered twice to the same group of students. There was a two-week time lapse between the first administration and the second one. The correlation coefficient was ascertained using Cronbach's Coefficient Alpha method (Gall, Borg & Gall, 1996). Correlation coefficient of 0.739 was obtained for MSCQ. This value of correlation coefficients was acceptable for the study, since Fraenkel and Warren (1990) assert that an alpha value above 0.70 is considered appropriate to make possible group predictions that are sufficiently accurate.

Data Collection Procedures:

Before the treatment started, the research assistants from participating schools were inducted for a period of two days by the researcher as pertains to the use of the PSA and conventional methods. This period was appropriate because the teachers involved in teaching the experimental and control groups were trained. They trained the students in the experimental groups pertaining to the requirements and use of PSA for a period of three days. To minimize differences in teachers' teaching approaches and ensure that emphasis was given to certain aspects of teaching, the researcher met with all the teachers involved in the study on weekly basis. In the meeting discussions on the content, problems as well as instructional approaches applied was done. The researcher wanted to make sure that the quality of teaching was decent and acceptable.

After the induction period, the research assistants administered a thirty-minute MSCQ to students in groups 1 and 2. MCSQ scripts were collected and scored for three days in each respective school by the researcher and his assistants. The pre-test scores were used to assess the entry level and homogeneity of the students in the randomly assigned experimental and control groups. The researcher and his assistants taught groups 1 and 3 the topic Commercial Arithmetics using PSA for a treatment period of three weeks. Groups 2 and 4 were taught the same topic using conventional methods where learning was mainly teacher-centred. It entailed the use of lectures, question/answer techniques, teacher-led discussions and worked-out class examples that were mainly teacher-dominated. In the process, the researcher observed some lessons.

Two days after the treatment period, the researcher and his assistants administered a thirty-minute MSCQ to the students in all the groups. The researcher visited the schools after two days to collect the data that was taken to a central marking point. The rate of return of data collection was 87.73 percent. The researcher with the help of the research assistants thus scored and coded the collected data. The pre-test and post-test results scores were then correlated and analysed.

Data Analysis Techniques:

The data obtained in the study constituted MSCQ pre-test scores and post-test scores of the experimental and control groups. The descriptive statistical tests that were done comprised of percentages, means and standard deviations. The inferential statistical tests; the t-test and the Analysis of Variance (ANOVA) were used to analyse data at an alpha level (α) of 0.05. The t-test was used to analyse the pre-test and the post-test influence. It was also used to compare whether students' mean scores were significantly different, based on the pre-test scores of experimental group 1 and control group 2. A comparison of mean scores and tests for significance difference between experimental and control group scores was done using ANOVA. An F-test was used to determine whether the differences were significant.

4. RESULTS

Results of Pre-test:

The Solomon Four-Group Design used in this study enabled the researcher to have two groups sit for pre-test. The aim for pre-testing was to ascertain whether or not the students selected to participate in this study had comparable characteristics before presenting the topic Commercial Arithmetics. To achieve this aim, the students in groups 1 and 2 sat for the pre-test MSC. This made it possible for the researcher to: assess whether there was any interaction between the pre-test and the treatment conditions; assess the influence of the pre-test relative to no pre-test; and assess the similarity of the groups before the administration of the treatment (Borg & Gall, 1989).

A total of 711 students were administered with pre-test MSCQ, of which 367 were in group 1 and 344 in group 2. Table 3 shows the t-test of the pre-test scores on the MSC.

Table 3: Independent Samples t-test of the Pre-test Scores on MSC

Experimental Group 1, N = 367 **Control Group 2, N = 344**

Variable	Group	Mean	SD	t-value	P-value
MSC	1	88.79[a]	22.42	0.568*	0.570
	2	89.88[a]	28.29		

Notes: [a,] denote similar mean scores * Not significant at p<0.05 level SD: Standard Deviation MSC Maximum Mean Score = 150 df = (1,709)

From Table 3, the experimental group 1 and the control group 2 attained means of 88.79 and 89.88 in MSCQ respectively. From the results, the pre-test mean scores of both groups (1 & 2) obtained were similar on MSC measure. The t-test results analysis reveal that the pre-test mean scores for groups 1 and 2 on MSC measure are not statistically different since the t-value for MSC (0.568), is not significant at 0.05 α-level, df = (1, 709).

An examination of the results in Table 3 indicate that the pre-test mean scores for experimental group 1 and control group 2 on MSC are not statistically different at 0.05 α-level. From the results presented in Table 3, it suffices that the pre-test

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MSC mean scores of students in the experimental group 1 and the control group 2 are not statistically different at 0.05 α-level. Also, it was assumed that the students were randomly assigned to classes at the Form one level and they continued in their intact classes until Form four. These indicate that the four groups used in the study were comparable and had similar entry behaviour, hence homogeneous. This made them suitable for the study.

Influence of PSA on Students' Mathematics Self-Concept in Commercial Arithmetics:

The post-test MSC scores were analysed to determine the influence of PSA teaching approach on students' mathematics self-concept in Commercial Arithmetics using one-way ANOVA. This was done in order to test hypothesis one (HO_1) that sought to find out whether there was any significant difference between the MSC of the students who were taught using PSA and those taught by the conventional methods. Table 4 shows the MSC post-test mean scores obtained by the students in the four groups.

Table 4: MSC Post-test Mean Scores Obtained by Students in the Four Groups

Group	N	Mean Score	SD
1	367	98.14[a]	24.79
2	344	92.91[b]	29.63
3	360	99.44[a]	25.01
4	388	91.97[b]	25.28
Total	**1459**	**95.59**	**26.36**

Notes: [a, b] denote similar mean scores   Maximum Mean Score = 150

An examination of the results in Table 4 show that the MSC post-test mean scores for experimental groups 1 and 3 (98.14 & 99.44) and that of the control groups 2 and 4 (92.91 & 91.97) respectively, are quite similar. However, the MSC post-test mean scores for the experimental groups 1 and 3 were much higher than that of the control groups 2 and 4. This suggests that the experimental groups (1 & 3) had higher MSC post-test mean scores than the control groups (2 & 4). From Table 4 the highest mean score was attained by group 3 (experimental group 2) followed by group 1 (experimental group 1) then group 2 (control group 1) and finally group 4 (control group 2). These means are presented graphically in Figure 1.

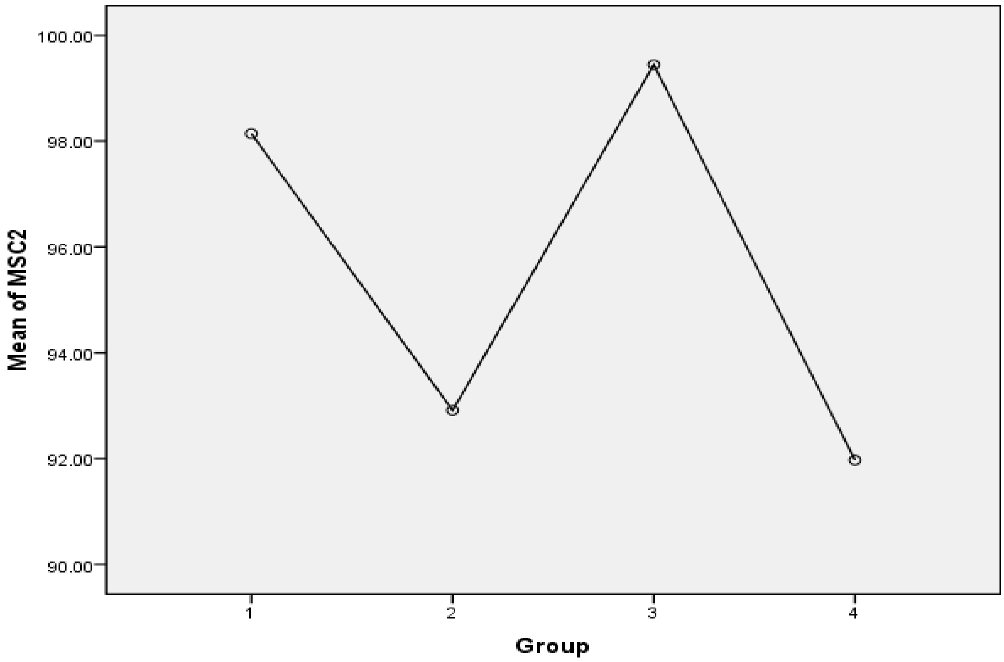

Fig. 1: Post-test means on MSC

In order to determine whether the difference in the MSC post-test mean scores was significant, a one-way ANOVA was performed. The results of the one-way ANOVA are shown in Table 5.

Table 5: ANOVA of the Post-test Scores on the MSC

Source of Variation	Sum of Squares	df	Mean Square	F	P-value
Between Groups	15283.49	3	5094.50	7.43*	0.00
Within Groups	997969.59	1455	685.89		
Total	1013253.08	1458			

Notes: * Denotes significant mean difference at the p<0.05 level df = (3,1455)

Table 5 shows that the difference in the post-test MSC mean scores is significant since the F-value (7.43) from ANOVA is significant at 0.05 α-level, df = (3, 1455). Having established that there was a significant difference between the MSC post-test mean scores, it was necessary to carry out further tests on the various combinations of the mean scores to find out where the difference occurred.

Table 6 shows the results of the LSD post hoc comparisons.

Table 6: Post Hoc Comparisons of Post-test of MSC Means for the Four Groups

	(I) Group	(J) Group	Mean Difference (I–J)	P- Value
LSD	1	2	5.23*	0.008
		3	-1.30	0.503
		4	6.17*	0.001
	2	1	-5.23*	0.008
		3	-6.53*	0.001
		4	0.94	0.628
	3	1	-1.30	0.503
		2	6.53*	0.001
		4	7.47*	0.000
	4	1	-6.17*	0.001
		2	-0.94	0.628
		3	-7.47*	0.000

Note: * = The mean difference is significant at the 0.05 level (2-tailed test)

From Table 6, the LSD post hoc comparisons indicate significant differences (p<0.05) between groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4. The differences between the mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 are not significant at 0.05 α-level (p>0.05). Since the MSC pre-test mean scores indicated that there was no significant differences between the entry levels of the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA).

Differences in the MSC post-test mean scores of the experimental groups 1 and 3 and the control groups 2 and 4 were not significant. It is also evident from Table 4, that the MSC post-test mean scores of the control groups 2 and 4 were almost similar and lower than those of the experimental groups 1 and 3.

The results indicate that the MSC pre-test did not interact significantly with the treatment conditions. If this were the case, the groups, which took the pre-test, would have obtained different results from those that did not take it (Borg & Gall, 1989). The pre-test MSC did not affect the students in the learning of the content. If this were the case, the students who sat for pre-test would have different results from the others. This made the pre-test suitable for the study (Kothari, 1990). The use of PSA resulted in higher students' MSC post-test mean scores than the conventional methods since the experimental groups 1 and 3 obtained significantly higher post-test mean scores.

From the results presented in Tables 4, 5 and 6, it suffices that the MSC post-test mean scores of students in the experimental groups 1 and 3 (98.14 & 99.44 respectively) are not statistically different at p = 0.05. Similarly, the MSC post-test mean scores of the control groups 2 and 4 (92.91 & 91.97 respectively) are not statistically different. However, the mean scores obtained by the students in groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 are significantly different at $p<0.05$. Thus, groups that were taught by PSA had high MSC post-test mean scores than those that were taught by conventional methods. In view of these findings, the null hypothesis one (HO_1) indicating that there is no significant difference between the MSC of the students who are taught using PSA and those who are taught by conventional methods is rejected.

Groups 1 and 2 responded to pre-test and post-test MSC. A comparison of their results is shown in Table 7, which also shows the corresponding paired samples t-test values for each group.

Table 7: Comparison of the Pre-test and Post-test Scores in MSC and Corresponding Samples t-values

Scale	Overall (N = 711)	Experimental Group 1 (N = 367)	Control Group 2 (N = 344)
Pre-test Mean	89.32	88.79[a]	89.88[a]
Post-test Mean	95.61	98.14	92.91
Mean Gain	6.29	9.35	3.03
df	710	366	343
t-value	16.52	18.00	6.02
p-value	0.00	0.00	0.00

Notes: [a] denotes similar mean scores   Maximum Mean Score = 150

Results in Table 7 show that the pre-test mean scores for experimental group 1 (88.79) and control group 2 (89.88) are quite similar. After the intervention, the experimental group 1 attained a mean score of 98.14, while the control group 2 that had no intervention got a mean score of 92.91. However, the experimental group 1 had a higher mean gain (9.35) in the MSC than the control group 2 (3.03). Thus, the experimental group improved more in their MSC than the control group. The net difference between the mean gains is 6.32. The overall mean gain on students' MSC was 6.29. The paired sample t-test between the pre-test and post-test mean scores though significant for the control group 2, (t-value 6.02 is significant at 0.05 α-level, df = (1, 343)), it is lower than that of the experimental group 1 which had a significantly higher post-test MSC mean since the t-value (18.00) is significant at 0.05 α-level, df = (1, 366). This indicated that PSA improved the students' MSC more than the control condition. This supports the fact that the PSA resulted in higher students' MSC than the conventional methods.

5. DISCUSSION

Results of the Pre-tests:

This study employed the Solomon Four-Group Design. The students were put in four groups such that groups 1 and 3 were the experimental groups while groups 2 and 4 were the control groups. Groups 1 and 2 took the pre-test while groups 3 and 4 did not take the pre-test. Such an arrangement enabled the researcher to determine the presence of any interaction between pre-test and the PSA treatment; determine the influence of the pre-test relative to no pre-test; determine the similarity of the groups before applying the treatment and generalise to the groups which had not received the pre-test (Sharma, 2002).

Sanders and Pinhey (1979) assert that when the two experimental groups (1 & 3) are similar to each other in the post-test as opposed to the two control groups (2 & 4), then the researcher is in a strong position to attribute the differences to the experimental condition. A greater difference in the post-test between the experimental groups 1 and 3 in comparison to that between the control groups 2 and 4 results if the pre-test interacts with the treatment. This is as a result of a sensitisation effect - that means the pre-test facilitates the learning of the experimental group in contrast to the control group. The post-test students' mathematics self-concept results in this study did not indicate any interaction between the pre-test and the PSA treatment.

Higher post-test performance by groups 1 and 2 than that of groups 3 and 4 could have been the results if the pre-test provided a practice effect. This is not the case since a comparison of the post-test results of the four groups fails to indicate any practice effect provided by the pre-tests. The results therefore portrayed that the pre-test MSC was suitable for the study.

A comparison of groups 1 and 2 students' pre-tests MSC mean scores revealed non-significant differences (Table 3). This results show that the groups were quite similar before the administration of the treatment.

Influence of PSA on Students' Mathematics Self-Concept in Commercial Arithmetics

The results of this study indicate that PSA resulted in higher students' mathematics self-concept than the conventional methods. The findings in this study revealed that the relationship between PSA and MSC is strong and statistically significant at $p = 0.05$ α -level of significance. The study findings are supported by Githua (2000) that students MSC is related to motivation to learn mathematics using effective teaching strategy. Similarly, the findings of the present study concur with Osang's (2010) findings that students' performance in mathematics depends on their MSC.

The students in the PSA classrooms were found to exhibit higher MSC towards the learning of mathematics. This seems to agree with the general notion that individuals can change their self perception and disposition through interactions with others. Hurme and Jarvella (2005) aver that small group co-operative work foster the development of students' reasoning skills. The selection of suitable tasks and the facilitation of peer interaction thus aid students' cognitive development during problem solving activities. Consequently, mathematics was developed in the PSA classes through socially-mediated cognitive experiences.

The high MSC attained in the PSA classes may also be explained by the fact that the social interactions among the students in the PSA groups were intense and prolonged. This is in agreement with the findings of Cokley (2000) in a study on an investigation of academic self-concept and its relationship to academic achievement in African American college students. Cokley found that the best predictor of academic self-concept for the students attending historically Black colleges and universities was the quality of student-teacher interactions. A study by Yara (2010) supports the view that academic self-concept and academic achievement are mutually reinforcing to each other to the extent that a positive or negative change in one facilitates a commensurate change in the other. This implies that the intervention, that is the PSA, is effective in enhancing students' MSC that leads to higher levels of mathematics achievement (Hemke, 1990).

Manger and Eikeland (2006) in their study of the effect of MSC on students' mathematics achievement found that Norwegian elementary schoolboys showed significantly higher MSC than the girls. The boys also had a significantly higher mathematics achievement scores than the girls. Gordon (2002) found that academic self-concept and academic achievement are related significantly to the school environment. Consequently, the teachers in the PSA classrooms enhanced the students' MSC positively by developing an organized, orderly and supportive environment.

A positive MSC among the students is an important goal of mathematics education in many jurisdictions (Mayer *et al.*, 2000). Examination of the major goals of education reveals unanimity of opinion that the development of mathematics culture includes development of positive MSC. Thus development of positive MSC is a critical component of mathematics instructions. It is judged imperative that students develop positive MSC at an early age and this favourable orientation be maintained (Gardner, 1991).

Development of positive MSC in a subject need positive atmosphere. One way of fostering positive MSC of students is by use of effective instructional methods. Instructions make mathematics more exciting and encourage students have a positive influence on their MSC as well as their achievement. Cokley (2000) and Grooves (2005) disagree with the notion that achievement in mathematics influences MSC, and offer the opposite relationship. They propose that the nature of mathematics instruction strongly affects students' MSC, which is a strong predictor of achievement in mathematics, mathematics learning, and the amount of mathematics a student will choose to experience.

The use of PSA as a teaching strategy in this study enhanced the development of positive MSC among the secondary school mathematics students. This was based on the anecdotal evidence from teachers as well as research findings suggesting that students' MSC is influenced by the instructional methods used. Grigutsch (2006) highlighted five conditions necessary to promote persistence within a course as expectations, support, feedback, involvement and learning. PSA as a teaching strategy offered students opportunity to integrate the five conditions into their mathematics classrooms. This enabled them to develop their knowledge base as well as improve on their MSC.

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Results on analyses of mean scores on MSC in this study showed that both the experimental and control groups students had favourable MSC. However, ANOVA analysis showed significant difference in MSC mean scores of students in the experimental groups (groups 1 & 3) and control groups (groups 2 & 4) at 0.05 α levels. The results imply that PSA teaching strategy as an intervention had significant contribution on the development of high MSC among the students in the experimental groups. This led to rejection of the null hypothesis HO_1 which stated that there is no significant difference between the MSC of students who learn using PSA and those who are taught using conventional methods.

The findings of this study are consistent with results obtained by Githua (2002) who also reported high MSC among secondary school students in Kenya. The findings are also in agreement with research findings in America and Australia that both boys and girls generally acquire high MSC when taught with appropriate instructional methods (Fredrick & Eccles, 2000; Jacobs *et al.,* 2002; Watt, 2004).

Science and Technology Education (STE) is attached a lot of value in the society among developing countries (Harding *et al.,* 1989). This is because mathematics as a science is not only instrumental in mathematics careers, but is also important in daily life experiences as well as in development of a nation as a whole. Kenya being one of the developing countries has laid a lot of emphasis in mathematics education, this need being more urgent at the moment if the envisaged goals in Vision 2030 are to be realized. In the recent past, STE has received a lot of support from all the determinants of education system; which include curriculum planners, school community, textbooks and material publishers. Perhaps it is as a result of these multi-directional campaigns that the students in the experimental groups, irrespective of their socio-background history attained high MSC as reflected by the findings of the current study.

Designing a motivating classroom environment is important in ensuring successful and fruitful learning. Incorporation of PSA strategy in the teaching of Commercial Arithmetics to Form Three mathematics students in the present study enhanced students' MSC level towards mathematics learning. MSC is a critical component of learning since it is important in getting students to engage in academic activities. It was also important in determining how much students learned from the mathematical problem solving activities they performed or the mathematical information to which they were exposed to. The students in the PSA classrooms who attained high MSC used higher cognitive processes in learning mathematics. In fact, those who attained high MSC were highly motivated to learn. Thus in a truly motivating classroom, students who have attained high MSC approach learning willingly because they view it as personally significant (Albanese & Mitchell, 1993).

The success of PSA on students' MSC can be attributed to the fact that the students were empowered by the teacher, and also that PSA is a student-centred teaching method. During PSA sessions, students felt more comfortable. Those who never participated in traditional classes made a great effort to join group discussions, and they really enjoyed leading the whole group process. The little group discussions on the way to solving problems really aroused an intrinsic interest in researching information about the topic of Commercial Arithmetics. Thus students' active engagement in the learning activities carried out in the PSA classrooms had a positive impact on their feelings about learning (that is, the notion of being responsible for and guiding their own learning). This in turn enhanced their MSC (De Volder *et al.,* 1986).

The mean MSC for experimental group 1 significantly gained more on posttest compared to pretest than that of control group 2 (Table 7). This difference could be attributed to the teaching method employed during the intervention period. ANOVA results showed statistically significant differences in the mean scores on MSC among the students in the experimental groups 1 and 3 in comparison to those in the control groups 2 and 4 (Table 5). This implies that the intervention, that is, PSA teaching strategy had a significant influence on MSC among the students in the experimental groups 1 and 3 compared to those in the control groups 2 and 4. These results were expected bearing in mind that effective instructional methods that encompasses students' participation in learning improve on affective characteristics of learners compared to conventional teaching methods (Lucas, 1990).

A common teaching approach in Kenya's secondary schools is the expository approach that is characterised by teachers who adopt a chalk-and-talk style that is heavily textbook oriented. As a result, learning becomes teacher-centred. This in turn fails to account for individual needs among the learners (Ayot & Patel, 1987; Gibbs, 1988; Montgomery, 1990; Changeiywo, 2001). In contrast to the expository approach, PSA built on the body of knowledge already possessed by the learners, enabled them to make effective use of the relevant learning resources, stimulated their interest and helped to create a suitable learning environment in the classroom (Shiundu & Omulando, 1992). The PSA also constituted problem-solving strategies that took into account the learners' needs. According to Good and Brophy (1995), Oloyende (1996) and Mondoh (1997), teachers can improve students' satisfaction in learning mathematics by being friendly and sensitive to their needs. This enhanced the students' mathematics self-concept, which in turn led to higher levels of achievement (Hemke, 1990).

The teacher, who served as a facilitator, created a conducive problem-solving environment, used group-work and facilitated the formation of positive attitudes towards problem solving. Students worked in collaborative groups as they received encouragement from fellow group members. This further enhanced their mathematics self-concept. This support the findings of Marsh (1990) that individuals change their self-concept with change in cognitive development, social situations, interactions with peers, teachers and institutions such as home and schools. Further, Marsh (1991) contends that maximising self-concept of ability in mathematics facilitates the attainment of academic achievement. Hence the higher achievement realised in the PSA classrooms.

Additionally, the teacher initiated and sustained students' interest in mathematics as well as encouraged them to engage in learning/problem-solving activities. This increased their confidence and interest in mathematics, which in turn aroused their curiosity to learn and achieve in the subject. Moreover, the teacher encouraged students to generate their own explanations why worked examples of problems were correct, represent problems and explain inductively principles underlying worked examples. Besides, the teacher gave clear and positive expectances to students, which further enhanced their mathematics self-concept (Horn, 1995). This strengthened the case of the teacher as being a facilitator in the teaching-learning process in the PSA classrooms. It is worth noting that PSA incorporated these problem solving techniques during instruction. In view of this, PSA enhanced students' mathematics self-concept, which aroused their interest in the subject and consequently improved their achievement. This agrees with Biehler and Snowman (1997) who found that high mathematics self-concept is essential in learning mathematics and is achieved when students feel that their competence in the subject is valued. Moreover, the findings of the current study support the findings of Ng'eno (2005) that students' mathematics self-concept correlates positively with their mathematics' achievement.

From the findings of this study, there is evidence that PSA as a teaching strategy has influence on the development of positive MSC among the students. All the students in the experimental groups 1 and 3 showed higher MSC in both the pretest and posttest analyses. This means that mathematics as a subject in the secondary school curriculum does not appear to be a disliked subject. This finding show that the perception of mathematics as a 'hard' subject in the secondary school curriculum is changing for the better. Mathematics teachers and educators in Kenya therefore should not entirely blame the poor achievement of students in mathematics on low MSC. Research has shown that achievement and MSC influence each other positively. However neither MSC nor achievement is dependent on the other, rather they interact with each other in a complex and unpredictable ways (Cokley, 2000). All the education stakeholders, and in particular the mathematics teachers in Kenya have a significant role to play in maintaining and strengthening these favourable trends in mathematics education by upholding positive MSC among the students in mathematics classrooms. Negative disposition towards mathematics, especially by the teachers, affects students adversely. It is therefore important that mathematics teachers demonstrate positive attitudes at all times in their dealing with students bearing in mind that teacher/student relationship and interaction is crucial for the students in their MSC development (Grigutsch, 2006).

The high MSC acquired by the students who were taught using PSA strengthens the case for the implementation of this approach in secondary school mathematics teaching. Once it is implemented, teachers will have an easier task, as they will deal with students with high mathematics self-concept.

6. CONCLUSION

The following conclusion has been drawn from the analysis of the data presented:

a) Students who are taught using PSA have higher mathematics self-concept to learn and achieve in mathematics than those who are taught using the conventional teaching methods.

b) The PSA positively influenced the students' mathematics self-concept that resulted in their autonomous learning and subsequent ownership of the lessons. Therefore, the PSA enhances students' mathematics self-concept than the conventional teaching methods.

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c) The difference in the students' mathematics self-concept is due to the PSA.

7. RECOMMENDATIONS

On the basis of the findings of this study, the researcher made recommendations that the mathematics educators as well as education stakeholders can employ the PSA to enhance effective and efficient mathematics classroom interactions between the teachers and the students. These recommendations are: -

(i) Mathematics teachers should note that mathematics students' acquire high MSC when instructed using the PSA. Mathematics teachers should therefore strive to maintain and enhance development of positive MSC by using effective and efficient teaching strategies which encourages students' participation and thus promote their motivation in mathematics learning.

(ii) Teacher Education curriculum developers should include the PSA in the training syllabus, thus making it part of the mathematics teacher education curriculum content.

(iii) The government should transform the textbooks of mathematics in problem based learning form, since the traditional textbooks do not meet the criteria of the PSA.

(iv) Extensive training programs, seminars and workshops should be organised for mathematics teachers in secondary schools to employ PSA in the classrooms. Of importance, the content of the PSA should be included in the regular in-service courses (e.g. Strengthening of Mathematics and Sciences in Secondary Education [SMASSE]) organised by the Ministry of Education for practicing teachers.

(v) Mathematics educators should encourage secondary school mathematics teachers to use PSA in their teaching since the use of this approach enhances students' mathematics self-concept that leads to higher levels of achievement

Based on the finding and conclusion made in this study, it is recommended that the PSA be adopted for mathematics instruction in Kenyan secondary schools.

Suggestions for Further Research:

The present study suggests that the PSA can be effective in improving mathematics instruction and enhancing students' mathematics self-concept. However, there are areas that warrant further investigation such as the following:

a) Investigation on the possible benefits derived from incorporating the use of computers in PSA on students' mathematics self-concept need to be carried out.

b) A similar study on the influence of PSA on students' mathematics self-concept should be carried out but using both qualitative and quantitative methods of data collections approach for concurrent triangulation and corroboration.

c) Systematic studies to determine the longevity or otherwise the influence of PSA on students' mathematics self-concept, motivation and interest, among other variables.

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