Novelty Journals

ISSN 2394-9686

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

Influence of Problem Solving Approach on Gender Differences in Mathematics Achievement in Vihiga County, Kenya

[1]Mutange Ronald Ellumbe, [2]Dr. Ong'unya Raphael, [3]Prof. Amadalo Maurice Musasia

[1, 2, 3] Department of Science and Mathematics Education, Masinde Muliro University of Science and Technology, P.O. Box 190-50100, Kakamega, Kenya
Tel: 0202633987, Fax: 056-30873, E-mail: mutangeronald89@gmail.com, Tel: +254 710 846 851

Abstract: **In Kenya, the fundamental challenge facing learning of mathematics in secondary schools is how to enhance students' conceptual understanding associated with the learning process. Based on this challenge, the present study investigated the influence of using Problem Solving Approach on gender differences in mathematics achievement in Commercial Arithmetics in Kenya. The purpose of this study was to establish the influence of Problem Solving Approach (PSA) on gender differences in mathematics achievement in Commercial Arithmetics in comparison to the conventional methods. 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 sub-county schools. The Solomon Four-Group design was used in the study. The respondents were assigned in their intact classes to four groups namely; 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 Achievement Test 1 and Mathematics Achievement Test 2 were used to collect data. The instruments' 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 was determined by Cronbach's Coefficient alpha formula. Reliability coefficients of 0.795 and 0.872 were obtained for Mathematics Achievement Test 1 and Mathematics Achievement Test 2 respectively. 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 increased learning occurred among students where Problem Solving Approach was used and that there are significant gender differences in mathematics achievement favouring boys. The researcher concluded that Problem Solving Approach is a more effective instructional approach to boys and girls of the problem solving group than to those of the conventional group. The Problem Solving Approach was helpful in enhancing the learning of mathematics, facilitated in making the subject easily understandable to both genders 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, Gender Differences, Mathematics Achievement.**

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

1. INTRODUCTION

1.1 Background to the Study:

Mathematics is one of the core subjects in the Kenya secondary school curriculum. It is an examinable subject for all students (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

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

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 (Watt, 2004). Affective characteristics thus form a base upon which meaningful learning can be promoted.

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.

To compound the problem of dismal performance due to inadequate teaching strategies, there is overwhelming evidence that the proportion of girls passing mathematics in KCSE is less than that of boys (KNEC, 2008-2010). The poor performance is attributed to various factors, which include lack of personnel, resources, textbooks among others (Githua, 2001; KNEC, 2010). Weiner (1978) attributes low girls performance to relative ways the sexes process learning. This theory suggests that girls are thought to have a brain which is predisposed to language based learning. Boys at this stage are thought to be more adept at analytical learning that combines logic and spatial orientation/manipulation skills. These are used in mathematics learning. Changeiywo (2001) argues that gender difference in learning mathematics may be associated with differences in cognitive styles. Changeiywo hypothesized that people inclined to adopt a serialist learning approach are disadvantaged when learning mathematics. According to Costello (1991), a greater proportion of girls than boys exhibit serialist preferences. Thus, when conceptual structures become more complex, and understanding of relationship of the systems become central to success in mathematics, the performance of girls drop accordingly. Moreover, during the teaching/learning process, the teacher-student interactions have a negative effect for the girls, who usually have lesser interactions with their teachers (Sanga, 1982; Maritim, 1984; Campbell, 1995). Further, Mondoh (1997) argues that mathematics in the classrooms has been depicted as a masculine subject. Usually the link between mathematics in the classroom and its relevance outside the classroom is lacking. These studies allude that teachers have been trained to approach mathematics instruction in a masculine way, making girls to fear it.

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). 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. This study investigated the influence of using PSA on students' mathematics achievement.

Problem solving instructions in schools do not emphasise techniques used by skilful problem solvers. In secondary school mathematics courses, the emphasis is usually on problem-specific procedures and mathematical manipulations to help students get answers, rather than the application of powerful ideals and generalisable procedures that could be applied across a wide range of contexts. The lack of emphasis on qualitative reasoning and integrating conceptual knowledge within problem solving instruction encourages rote memorisation of procedures and formulaic approaches that do little to foster conceptual understanding. The problems that students solve illustrate a single path to a single answer; the notion that a problem may have multiple solutions or multiple paths to a solution is not stressed. Anderson and Roth (1989) observed that at the primary school level, the solutions to the "problems" that pupils are given usually require only single answer. In respect to this, pupils do not solve problems but rather answer questions. Moreover, students are not given open-ended problems that require to be broken into smaller sub-problems, to device mathematical methods for answering the sub-problems, or to summarise the knowledge learned from solving problems in a form that makes it conducive to apply it in novel contexts.

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 (2005) 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 (2000) 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 Problem Solving Approach (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 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.

From the foregoing, none of the studies so far sought to establish the influence of Problem Solving Approach (PSA) on gender differences in mathematics achievement in Commercial Arithmetics with an aim of promoting meaningful learning. In an attempt to fill this gap, the current study investigated the influence of PSA on gender differences in mathematics achievement in Commercial Arithmetics in secondary schools in Vihiga County.

1.2 Purpose of the Study:

The purpose of this study was to establish the influence of Problem Solving Approach (PSA) on gender differences in mathematics achievement in Commercial Arithmetics in comparison to the conventional methods.

1.3 Objective of the Study:

The objective of the study was to establish whether there is any gender differences in mathematics achievement of students taught using PSA as compared to those taught by the conventional methods.

1.4 Hypothesis of the Study:

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

HO_1: There is no significant gender differences in mathematics achievement scores of students taught using PSA compared to those taught by the conventional methods.

1.5 Significance of the Study:

The findings of the present study would contribute to both theory and practice of mathematics education in Kenya's secondary schools. In terms of theoretical value, the findings would help teacher educators at the teacher training colleges and universities and curriculum developers at the Kenya Institute of Curriculum Development (KICD) to understand the dynamic components of PSA: face-to-face positive interaction, positive interdependence, individual accountability, and collaborative skills that make it an effective instructional method that should be recommended for teaching students in secondary schools. This will assist in the review of the secondary school mathematics' syllabi and instructional objectives.

In terms of practical value, the findings would help teachers and quality assurance officers to emphasize on using PSA to improve on academic achievement in mathematics. Students stand to gain higher levels of achievement, to build cross-ethnic friendship, to build lifelong interaction and communication skills and master the habits of mind (critical, creative and self-regulated learning) needed in society if they learn in PSA environment.

2. LITERATURE REVIEW

2.1 Problem Solving Approach and Achievement in Mathematics:

The Principles and Standard for School Mathematics (NCTM, 2000) describes Problem Solving Approach as using interesting and well-selected problems to launch mathematical lessons and engage students. In this way, new ideas, techniques and mathematical relationships emerge and become the focus of discussion. Good problems can inspire the exploration of important mathematical ideas, nurture persistence, and reinforce the need to understand and use various strategies, mathematical properties, and relationships. Problem solving is thus the process of confronting a novel situation, formulating connections between the given facts, identifying the goal, and exploring possible strategies for reaching the goal. The aim of this approach is acquisition of information that is based on facts (Yuzhi,2003; Mangle, 2008).

PSA is a constructivist teaching model based on the assumption that learning is a product of cognitive and social interactions originating in a problem focused environment (Greeno et al, 1996). The theoretical philosophy of this approach is derived from John Dewey and discovery learning (Rhem, 1998). Fundamentally, PSA is an educational method in which students develop critical thinking and problem-solving skills in addition to developing an understanding of grasping essential concepts through the analysis of real-life problems (Duch, 1995). Learning takes place throughout a process where learners solve problems in groups. Barrows (1996) labels the main characteristics of PSA as: learning is student-centred and takes shape in small groups of students; teacher act as moderator and facilitator; the problems provide motivation for learning and organizational focus as well as the basis for the advance in problem-solving skills; and self-directed learning aids the acquisition of new information. Besides equipping students with knowledge, PSA could also be employed to improve their problem solving skills, critical and creative thinking abilities, lifelong learning aptitudes, communication skills, group co-operation, adaptation to change and self-evaluation abilities, and enables them to build a far more positive approach to learning (Albanese and Mitchell, 1993).

In PSA, students act as professionals (Gallagher et al., 1999). They are confronted with problems that require clear defining and well structuring, developing hypothesis, assessing, analysis, utilizing data from different sources, revising initial hypothesis as the data collected, developing and justifying solutions based on evidence and reasoning. PSA has been used as an educational tool to enhance learning as a relevant and practical experience, to have students' problem solving skills and to promote students' learning skills. Eng (2001) opined PSA as a philosophy aims to design and deliver a total learning that is holistic to student-centred and student empowerment. Presenting the students with a problem, gives them opportunity to take risks, to adopt new understandings, to apply knowledge to work in context and to enjoy the thrill of being discovers.

Tick (2007) notes that in the student-centred learning environment that is desirable for PSA, the student is the central figure of the learning-teaching process. The learning objective is not the reproduction, recall and learning of passively received learning material. Rather, it is the active and creative engagement of students in group work and in individual study, thus transferring the skills and knowledge. The individual, autonomous self-directed learning gives the freedom to the learner to decide individually and consciously on the learning strategy and on the time scale to follow. Students have the opportunity to express their ideas and justify their answers verbally. They also have opportunities to engage in cognitively demanding questions (Hiebert & Wearne, 1993).

In PSA, the teacher acts as a facilitator. Roh (2003) argues that within problem solving learning environments, teachers' instructional abilities are more critical than in the traditional teacher-centred classrooms. Beyond presenting knowledge to the students, teachers must engage students in marshalling information and using their knowledge in applied and real settings. In teaching through problem solving, the discussion of a problem and its alternative solution takes longer than the demonstration of a routine classroom activity. Hiebert and Wearne (1993) found that classrooms with a primary focus on teaching through problem solving used fewer problems and spend more time on each of them compared to those classrooms without a primary focus on problem solving. Moreover, in problem solving classrooms, teachers ask more conceptually-oriented questions and fewer recall questions than teachers in the conventional classrooms. They also decide the aspects of a task to highlight, how to organize and orchestrate the work of students, what questions to ask to challenge those with varied levels of expertise, and how to support students without taking over the process of thinking for them and thus eliminating the challenge (Stigler & Hierbert, 1999). Thus it is the teacher's role to develop students' reasoning skills. As Weber (2008) avers, "To lead students to develop accurate criteria for what constitutes a good argument, the teacher must have a solid understanding of these criteria" (p. 432).

Learning takes place during the process of problem solving. As students solve problems, they can use any approach they can think of, draw on any piece of knowledge they have learned, and justify their ideas in ways they feel are convincing. The learning environment provides a natural setting for students to present various solutions to their group or class and learn mathematics through social interactions, meaningful negotiations, and reaching shared understanding. Such activities help students clarify their ideas and acquire different perspectives of the concept or idea they are learning (Lester & Charles, 2003).

PSA has important cognitive learning outcomes such as subject achievement, retention, problem-solving skills, learning strategies, approaches to learning (Berkel and Dolmans, 2006; Chin and Chia, 2004). Problem-based tutorial groups positively influence learning. In studies focusing on the cognitive effects of small groups PSA, activation of prior knowledge, recall of information, causal reasoning or theory building, cognitive conflicts leading to conceptual change and collaborative learning construction take place during discussions (Dolmans and Schmidt, 2006). In PSA, students follow a certain pattern of exploration which begins with the consideration of a problem consisting of occurrences that need explanations. During discussion with peers in groups, students try to identify the fundamental principles or processes. Students then stimulate their existing knowledge and find that they need to undertake further study in certain areas. As a result of this, students research the necessary points and then discuss their findings and difficulties within their groups. The discussions held in groups contribute to students' cognitive learning positively (Dolmans et al., 2001).

PSA impacts students' motivation for learning optimistically. A certain cognitive process (i.e. intrinsic interest in subject matter) is facilitated by the process entailed in PSA (Schmidt, 1993). By discussing the subject matter in groups, students become engaged which in turn influences their inherent interest in the subject matter (Dolmans & Schmidt, 2006). Students' intrinsic interest motivates them to develop a full understanding of all the components needed for its solution (Grooves, 2005). Consequently, these cognitive and motivational benefits of PSA have a positive resultant impact on student's academic achievement.

According to Dart et al. (2000), PSA produces deep learning which is a modernist method where the leaner actively participates in the learning task so as to reshape the knowledge provided. The surface learning is a product of the conventional method where the learner is completely passive waiting for the teacher to transfer the information directly. Researches have proved that students get influenced by their perceptions of the learning environment when selecting an approach to learning (Trigwell et al, 2000; Wasike, 2003; Mayya et al., 2004). In earlier studies, Raimsden and Entwistle (2010) reported that teaching characteristics such as the methods of learning employed in classes, the teacher's enthusiasm, the level of the knowledge being taught and the pace of progression have a great impact on students' achievement. Margetison (2008) noted that conventional methods of teaching encourage the leaner to adopt the surface learning approach; and that it is PSA method that integrates the four vital elements of the deep learning approach; that is a well-structured knowledge database, active learning, interaction through co-operation and the conditions planned in a way to increase intrinsic motivation.

Mathematical problems are well structured in that they are clearly stated, have known solutions and are evaluated against well known undisputed criteria. Biehler and Snowman (1997) indicate that mathematical problems have given information, obstacles and a goal. According to Polya (1973) the four steps that can help a learner to successfully solve mathematical problems are: identification of the problem, which depends on curiosity and interest of the learner in the subject matter; understanding of the nature of the problem based on specific-domain knowledge and familiarity with problem types; recall of mathematical facts and consultation with other relevant source for the required information in a problem; and formulation and implementation of solution to a problem through; use of algorithms, heuristics, study of worked examples, solution of similar but simpler examples, solving analogous problems, and evaluating the solution by estimating or checking its solution.

In support to Polya's four-step sequence, Kelly, Lang and Pagliaro (2003) identified eight problem solving strategies namely: identifying the target goal (what is to be solved), making a plan, identifying the key information, evaluating one's plan and solution, generating and testing hypothesis, estimation, trial-and-error and dividing a problem into sub-problems (two or more procedural operations). Problem-solving strategies are key to enabling students to continue their learning far beyond the classroom, leading them to become autonomous learners. Successful problem-solvers draw on a variety of strategies, use knowledge of patterns within their topic, make certain that they understand a problem before attempting a solution, and use effective self-regulation during the process. Once they understand the problem, they develop an initial plan, carry it out and reflect on the success of the solution (Polya, 1973; Kelly et al., 2003).

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

In regard to mathematics specifically, a difficulty in some curricular is that algorithms are taught out of context. Lochhead and Zietsman (2001) argue that teaching must be done within the context in order to avoid students' perfunctory performance on algorithms alone. They further assert that much emphasis is on general-purpose strategies that can be applied across a range of mathematical contexts. Beyer (1988, 2001) supports Polya's four-step sequence of introducing mathematical problem solving. The teachers reinforce this strategy and elaborate upon it as student progress through the classes, using it as a framework for a variety of solution plans and formulae.

Cook (2001) stresses tasks that engage students in problem-solving and mathematics reasoning. Cook argues that quality rather than quantity should rule the day in problems that are thought-provoking and those that challenge students' curiosity. Students can also gain from learning strategies such as: trial-and-error, drawing a diagram or model, process of elimination, looking for patterns, simplifying the problem, working backwards, organizing information and then writing an equation. Lochhead and Zietsman (2001) contend that good problem-solvers have these strategies as part of their repertoire. Besides, they have a positive and determined attitude about problem-solving, and awareness in the sense of understanding *how* they solved the problems. This study used Polya's problem solving heuristics during mathematics instruction.

Studies involving elementary students showed that students taught through the PSA had higher levels of mathematical understanding and problem solving skills on a computation test than those taught with the conventional methods (Carpenter et al., 1998; Fuson et al., 2000). Other studies involving middle school students (Ridgeway et al., 2002; Romberg & Shafer, 2002) revealed that students taught with the problem based instruction had higher levels of mathematical understanding than the students taught by the traditional instruction. Earlier, Wood and Sellers (1997) found that students who received problem-centred mathematics-instruction had significantly higher achievement on standard achievement measures and better conceptual understanding than did those students who had received the traditional instruction. In studies involving pre-service Physics teachers, those taught through problem based learning (herein referred to as the PSA) instruction had higher levels of achievement in comparison to those who received instruction through the traditional methods (Segzin, 2009). Although the literature reviewed supports the benefits of PSA, none of the studies focused on the influence of PSA on gender differences in mathematics achievement in Vihiga County schools.

2.2 Gender and Achievement in Mathematics:

Gender differences in mathematics achievement is a great controversy issue in educational domain and research documents show great discrepancies among boys and girls achievement in mathematics. Springler and Alsup (2003) indicate that there is no gender difference on the mathematical reasoning ability at elementary school level. However, Gallagher et al. (1999) allude that gender differences in mathematical ability at high school, favour boys than girls. This happens when mathematics become more abstract. Moreover, O'Connor et al. (2004) are of the view that gender differences in mathematics achievement become apparent at the secondary school level when girls begin to exhibit less confidence in their mathematics ability and perform lower than the boys on problem solving and higher level mathematics tasks. Research evidences show that gender differences in mathematics achievement are due to various factors such as; biological factors (Geary & Hoard, 2000), mathematics learning strategies (Carry & Jessup, 1997), sex hormones on brain organization and symbolic gender (Kimura, 2002).

Current research findings in Kenya indicate that gender difference in mathematics achievement begin to appear at upper primary school level and increase in the secondary school. This gender difference in achievement is attributed to the interaction of factors outside the school system or the background factors of the students and factors within a school environment (Kirembu, 1991; Makau & Coombe, 1994). Farrel (1993) argues that students' achievement in developing countries is much influenced by factors within a school.

Mondoh (1997) concurs with Eshiwani (1975) that mathematics in our classrooms has been depicted as being a masculine subject. Besides, the link between mathematics in classroom and its relevance outside is lacking. The teachers have been trained to handle it in a very masculine way, making girls to fear it. Thus, it was better if an approach that was more flexible, catering for both girls and boys fairly was adopted. As such, this study investigated the influence of PSA on students' mathematics achievement among boys and girls. Perhaps it may be more vital to girls who seem to prefer a method that is stimulating and motivating while boys seem to prefer the conventional methods that are masculine-oriented.

Studies have shown that teaching approaches where students are taught in a traditional environment are positive for girls. Boys have advantage in creative environments where they are able to take risks and solve problems (Rodd & Bartholomew, 2006; Scott-Hodgetts, 1986). Rogers (1995) and Burton (1995) are of the view that the instruction of mathematics as a complete body of knowledge affects girls in a negative way than boys. Boaler (1997) is of the opinion that girls should not be blamed for not participating in classroom discussions and for underachievement. This is due to the classroom norms that frequently serve to exclude them.

Sammuelsson (2008) found that boys and girls who were taught mathematics by PSA performed equally well. This is so because, in the PSA learning environment, the teacher, serving as a facilitator, is responsible for structuring favourable classroom environment that allows the students to work interactively in collaborative groups. The students in the PSA classrooms, irrespective of their gender, have equal opportunities to interact and participate fully in the learning and problem-solving group activities. The PSA assists the mathematics teacher to balance the classroom interaction patterns between boys and girls. By using this approach, the teacher is able to give similar attention to boys and girls and this can lead to improved achievement by both. Although the literature reviewed supports the benefits of PSA to boys and girls performance in mathematics, there was scanty literature focusing on the influence of the PSA on boys and girls achievement in Vihiga County schools. Thus this study investigated on the influence of PSA on gender differences in mathematics achievement in Vihiga County schools.

3. RESEARCH METHODOLOGY

3.1 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. 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 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

Novelty Journals
ISSN 2394-9686
International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

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.

3.2 Description of 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.

3.3 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' achievement in terms of conceptual understanding in Commercial Arithmetics. This has been blamed on the teaching strategies, 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 cognitive characteristics of the learners if the low mathematics achievement has 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 (Githua, 2002). The county has 114 schools: 2 national schools, 10 county schools, 97 sub-county schools and 5 private schools. National, county and sub-county 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.

3.4 Sampling Procedure and Sample Size:

The sampling frame consisted of all national, county and sub-county 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 sub-county 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.

3.5 Research Instruments:

According to Sharma (2002), no single method of data acquisition is sufficient. Thus, using more than one method of collecting data is recommended. As such, two instruments namely; Mathematics Achievement Test 1 (MAT 1) and Mathematics Achievement Test 2 (MAT 2) were used to collect data to meet the objective of the study. They were developed and pilot tested prior to the actual conduct of the study. The items in the tests were based on the table of specification designed for the topic Commercial Arithmetics against the three cognitive levels (knowledge, application & comprehension) as stated in the Blooms taxonomy. MAT 1 was used as a pre-test and had items on the topic Commercial Arithmetics covered at the Form one level. The topic is covered in the Form one syllabus and it builds the foundation for Commercial Arithmetics topic taught at the Form Three level which was the focus of this study. It was administered during the first week of the study. Its purpose was to establish the entry behaviour of the learners before the treatment. MAT 2 was given to six University lecturers who gave their comments after studying the items. Language and other noticeable problems were corrected. The test was then given to three secondary school mathematics teachers who were also examiners with the KNEC. They reviewed the items and made their comments. Their feedback was used to improve the test items. The improved test (MAT 2) contained fifteen items and was used as a post-test. It was used to assess Form three students' achievement in Commercial Arithmetics after the treatment. It was administered after the treatment when all the lessons had been taught. The instruments were 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 instruments.

3.6 Validity of Instruments:

MAT 1 and MAT 2 were assessed for content and face validity. 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 MAT 1 and MAT 2 for content coverage and level of difficult. Their responses were measured on a five-point Likert scale. 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 averages of the responses of the face and content validity of each of the instruments are as shown in Table 2.

Table 2: Summary of Assessment of Instruments' Validity by Percentage

Instruments	Type of Validity	Mathematics Teachers	Academic Supervisors	Mathematics Educators	Average Percentage	Conclusion
MAT 1	Face	86	74	78	79.33	Appropriate
	Content	88	85	94	89.00	Appropriate
MAT 2	Face	87	82	86	85.00	Appropriate
	Content	90	88	92	90.00	Appropriate

3.7 Reliability of Instruments:

The reliabilities of MAT 1 and MAT 2 were ascertained using test-retest method. The instruments were 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 coefficients were ascertained using Cronbach's Coefficient Alpha method (Gall, Borg & Gall, 1996). Correlation coefficients of 0.795 and 0.872 were obtained for MAT 1 and MAT 2 respectively. These values of correlation coefficients were 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.

3.8 Development and Use of Instructional Materials:

The instructional materials used in the study were based on the KICD approved mathematics syllabus (KICD, 2002). The Secondary Mathematics Students' Book Three by KICD was used as the textbook in the control group. In the experimental group, the PSA module was used. The module had two manuals, one for the teacher (Teachers' manual) and one for the students (Students' manual). The Teachers' manual was derived from the Students' manual. These manuals contained the mathematics content that was covered during the instructional process. The Teachers' manual is a written copy of all of the steps a student needs to take during the lesson (that is, defining the problem, determining the learning goals, reaching new information by researching, doing numerical analysis of the problem etcetera). In the Students' manual, the previously mentioned parts were left empty for the students to complete.

In the beginning of the PSA sessions, the copies of the modules were distributed to each student and teacher. The teachers' instructional manual generally described the methodology that was used in teaching the topic of Commercial Arithmetics. These included a detail description of the specific teaching approach tested in the present study; the instructional method and teaching/learning activities as well as how the specific mathematics concepts and skills were to be presented in the topic. Detail description of all the procedures were necessary to ensure uniformity as much as possible among the teachers involved in the study.

3.9 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. Teachers in the experimental groups were also issued with instructional manuals specifically developed for the topic of Commercial Arithmetics.

After the induction period, the research assistants administered a ninety-minute MAT 1 to students in groups 1 and 2. The MAT 1 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.

Two days after the treatment period, the researcher and his assistants administered a ninety-minute MAT 2 to all the four groups at the same time. 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. To ensure uniformity in the marking, the MAT 2 scripts were scored using the belting system as currently advocated by the KNEC. The pre-test and post-test results scores were then correlated and analysed.

3.10 Data Analysis Techniques:

The data obtained in the study constituted of MAT 1 pre-test scores and MAT 2 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

4.1 Results of Pre-tests:

The Solomon Four-Group Design used in this study enabled the researcher to have two groups sit for pre-tests. 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 MAT 1. 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 in the experimental group 1 and control group 2 were administered with pre-test MAT 1 of which 323 were males and 388 were females. Table 3 shows a summary of the pre-test scores on MAT 1 based on students' gender.

Table 3: Independent Samples t-test of the Pre-test Scores on MAT 1 based on Students' Gender

Variable	N	Gender	Mean	SD	t-value	P-value
MAT 1	323	Male	37.46[a]	9.54	0.786*	
	388	Female	38.01[a]	9.10		0.432

Notes:

[a] denotes similar mean scores * Not significant at $p<0.05$ level

MAT 1 Maximum Mean Score = 100 df = (1,709)

The results in Table 3 indicate that the male students had a mean score of 37.46, while that of the female students was 38.01. The t-test result indicates that the MAT 1 pre-test mean scores of the male and the female students are not statistically different since the t-value for MAT 1 (0.786) is not significant at 0.05 α-level, df = (1, 709).

An examination of the results in Table 3 indicate that the pre-test MAT 1 mean scores of the male and female students in the experimental group 1 and the control group 2 on MAT 1 are not statistically different at $p<0.05$ α-level. Also, 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.

4.2 Influence of Problem Solving Approach on Achievement of Boys and Girls in Commercial Arithmetics in Comparison to Conventional Methods:

In order to determine the influence of PSA on achievement among the boys and the girls, an analysis of the students' post-test MAT 2 mean scores was carried out. This was done in order to test hypothesis three (HO_1) of the study that sought to find out whether there was any significant gender differences in mathematics achievement scores of students who were taught using PSA and those who were taught by the conventional methods. The MAT 2 post-test mean scores obtained by the boys and girls in the experimental and the control groups are presented in Table 4.

Table 4: MAT 2 Post-test Mean Scores Obtained by Boys and Girls in the Four Groups

Group	N	Mean Score	SD
Experimental Boys	400	54.63	10.21
Control Boys	342	42.94	13.51
Experimental Girls	327	51.44	8.79
Control Girls	390	35.45	9.67
Total	**1459**	**46.05**	**13.14**

Note: Maximum Mean Score = 100

From Table 4, the experimental groups had 400 boys and 327 girls. The control groups had 342 boys and 390 girls. An examination of the results reveals that the boys in the experimental group attained a higher mean score of 54.63 than that of the boys (42.94) of the control group. Similarly, the girls in the experimental group scored a mean of 51.44 that was higher than that of the girls of the control group which was 35.45. The highest mean score of 54.63 was attained by boys of the experimental group, followed by a mean score of 51.44 for girls of the experimental group, then a mean score of 42.94 for boys of the control group and finally a mean score of 35.45 for girls of the control group. These means are presented graphically in Figure 1.

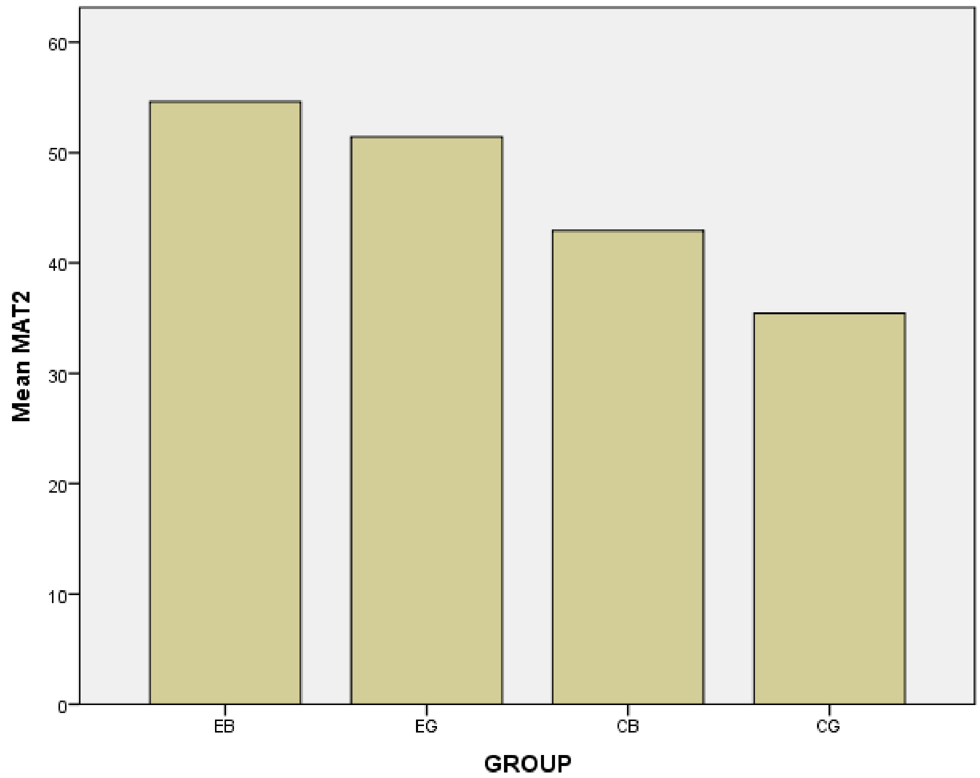

Fig 1: Post-test Means on MAT 2 for Boys and Girls

Key: EB = Experimental Boys EG = Experimental Girls

CB = Control Boys CG = Control Girls

From the results presented in Table 4, it is evident that the boys and the girls of the experimental groups outperformed their counterparts of the control groups. The results portray that PSA exerted a significantly higher influence on the achievement of boys and girls than the conventional methods.

In order to determine whether the difference in the MAT 2 post-test mean scores was statistically significant, a one-way ANOVA was performed. The results of the one-way ANOVA based on these mean scores are shown in Table 5.

Table 5: ANOVA of the Post-test Scores on the MAT 2 for Boys and Girls

Source of Variation	Sum of Squares	df	Mean Square	F	P-value
Between Groups	86104.55	3	28701.52	252.18*	0.00
Within Groups	165602.28	1455	113.82		
Total	251706.83	1458			

Notes: *Denote significant mean differences at p< 0.05 level df = (3,1455)

From the results in Table 5, the F-value (252.18) from ANOVA is significant at $p<0.05$ α-level, df = (3, 1455). This indicates that the MAT 2 post-test mean scores of the groups are significantly different.

Having established that there was a significant difference between the means, it was necessary to carry out further tests on the various combinations of means to find out where the difference occurred. Table 6 shows the results of the Least Significance Difference (LSD) post hoc comparisons.

Table 6: Post Hoc Comparisons of the Post-test of MAT 2 Means for Boys and Girls in the Four Groups

	(I) Group	(J) Group	Mean Difference (I–J)	P-value
LSD	EB	EG	3.18*	0.00
		CB	11.69*	0.00
		CG	19.18*	0.00
	EG	EB	-3.18*	0.00
		CB	8.50*	0.00
		CG	15.99*	0.00
	CB	EB	-11.69*	0.00
		EG	-8.50*	0.00
		CG	7.49*	0.00
	CG	EB	-19.18*	0.00
		EG	-15.99*	0.00
		CB	-7.49*	0.00

Notes: * = The mean difference is significant at the p<0.05 level

EB: Experimental Boys EG: Experimental Girls

CB: Control Boys CG: Control Girls

The results in Table 6 show that there was a statistically significant difference in the pairs of MAT 2 post-test mean scores of: boys of the experimental group and girls of the experimental group; boys of the experimental group and boys of the control group; boys of the experimental group and girls of the control group; girls of the experimental group and boys of the control group; girls of the experimental group and girls of the control group; and boys of the control group and girls of the control group. Since the MAT 1 pre-test mean scores indicated that there was no significant gender difference in mathematics achievement between the groups involved in the study, then it was not necessary to confirm the post-test results by performing Analysis of Covariance (ANCOVA).

The results indicate that both PSA and conventional teaching methods significantly improved the achievement of both gender in mathematics. This implies that both the treatment (PSA) and the conventional teaching methods significantly influenced the achievement of boys and girls of the experimental and the control groups respectively. Therefore gender does influence students' achievement in mathematics irrespective of the teaching strategy (PSA or conventional methods) used. In view of these findings, the null hypothesis HO_1 indicating that there is no significant gender differences in achievement of students who are taught using PSA and those who are taught by the conventional methods is rejected.

5. DISCUSSION

5.1 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 achievement result 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 MAT 1 was suitable for the study.

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

5.2 Influence of Problem Solving Approach on Achievement of Boys and Girls in Commercial Arithmetics in Comparison to Conventional Methods:

The results of this study have shown that there are significant difference between the achievement of boys and girls who are taught Commercial Arithmetics using PSA in Vihiga County schools. When the achievement of boys is compared to that of girls, the results showed that the MAT 2 post-test mean scores of boys were significantly higher than that of girls in the two experimental groups 1 and 3 (Table 5). Thus the PSA was more beneficial to boys than to girls. It can therefore be argued that PSA has varying effect depending on students' gender in a particular school type. The boys seem to have obtained the greatest benefit from the PSA teaching method. However the overall results show that boys and girls who are taught using PSA perform significantly better than those who are taught using the conventional methods. Therefore, PSA appears to be more effective in enhancing students' achievement in mathematics than the conventional teaching methods.

The results of this study echoed the findings of Mondoh (1997) and Makau (1994) that gender difference in mathematics is at a higher level in Kenyan secondary schools. This is attributed to the interaction of factors outside the school system or the background factors of the students and factors within the school environment. Moreover the findings come in support of Rodd and Bartholomew (2006) that boys have advantage over girls in mathematics achievement in that they are very creative in environments where they take risks and solve problems. However, Rogers (1995) and Burton (1995) are of the view that the instruction of mathematics as a complete body of knowledge affects girls in a negative way than boys. The present results attest to this. Gallagher and Kaufman (2006) agree with Hyde et al. (1990) that there is a gender difference in mathematical ability at high school, favouring boys than girls. Moreover, O'connor et al. (2004) concurs with Hyde et al. that gender differences in mathematics achievement become apparent at the secondary school level when girls begin to exhibit less confidence in their mathematics ability and perform lower than the boys on problem solving and higher level mathematics tasks. The results of the current study concur with the findings of Hyde et al., O'connor et al., and Gallagher and Kaufman.

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

The findings of the present study however contradict the findings of Samuelsson (2008) and Springler and Alsup (2003). Samuelsson's results showed that the use of PSA aroused and maintained a high level of motivation and interest among students during the lessons, and promoted interactions between the teacher and the students. This made the boys and girls perform equally well in the PSA classrooms. Samuelsson's findinds are consistent with the earlier findings of Caplan and Caplan (2005) who ague that the link between gender and mathematics achievement is very weak. Springler and Alsup allude that there is no gender differences on the mathematical reasoning ability at elementary school level.

The significant gender differences in mean scores on MAT 2 between boys and girls taught using PSA was however not anticipated. The negative results from this study were probably due to the short intervention period (i.e. 3 weeks). Research has demonstrated that PSA as a teaching strategy requires lengthy time for mastery before one appreciates its usefulness (Hiebert & weirner, 1993; Sungur et al., 2006). Sezgin (2009) is of the view that positive influence of PSA might be achieved in studies that has a long treatment period (above 4 weeks). In support of this, Samuelsson's (2008) study found that those students who used PSA in mathematics achieved significant results and had improved conceptual understanding after a 10 week intervention. Elsewhere, for example, Novak, Gowin & Johansen (1983) found that 7th and 8th grade science students who used concept mapping demonstrated superior problem-solving performance after six months of use. Thus the short period of intervention in the present study was unlikely to have had any significant influence on gender difference in mathematics achievement.

The Forum for African Women Educationists (FAWE), cited in Wachanga (2002), in a study aimed at improving the participation and performance of girls in mathematics and sciences in primary and secondary schools, reported that girls' achievement in mathematics in Kenya was much lower than that of boys partly due to their negative attitude towards mathematics. Further, it reported that the teacher in the normal competitive classes consciously and unconsciously discourage girls' participation in learning. For example, some teachers assume that girls would be unable to answer certain types of questions or perform certain mathematical activities. Other teachers make remarks that indicate that they feel that girls are unintelligent and lazy. According to Campbell (1995), boys receive more praise and teacher initiated contacts while girls are criticised more frequently for the academic quality of their work. This differential treatment can contribute to faulty perceptions that mathematics is a male domain. Sadker and Sadker (1986) revealed that male and female teachers give more attention to boys than to girls in secondary schools. This practice has the effect of reinforcing in girls the belief that they are less capable, which in turn negatively affects their self-esteem and confidence resulting in poor achievement.

This study has shown the interactiveness of the lesson components. In agreement with earlier studies in America and Kenya, that indicates that some students have greater interaction with their teachers than others do (Sanga, 1982; Maritim, 1984; Sadker & Sadker, 1986; Campbell, 1995), the findings of this study failed to place all the students on the same level. This implies that the boys in the PSA classrooms had more opportunities to interact and participate fully in the lessons leading to their higher level of achievement. Indeed, studies have shown that collaborative socialisation during the teaching and learning process is critically important in students' achievement (Eshiwani, 1983; Kirembu, 1991; Okere, 1996; Githua, 2002; Wachanga, 2002; Wasike 2003; Wekesa, 2003). This seems to have been the case for the boys in both the experimental and control groups who participated in the study.

It is argued that the PSA assist the mathematics teacher in balancing the classroom interaction patterns between boys and girls. By using PSA, the teacher is able to give similar attention to boys and girls and this can lead to improved achievement by both sexes. The current study contradicts this. In this regard, it is evident that the disparity between girls' and boys' achievement in Vihiga County schools at KCSE mathematics examinations may not be fully addressed by using the PSA.

Indeed, the PSA enables the students to state exactly what the problem is, search for a strategy by identifying the structure of the problem, use the search model identified to solve the problem, interpret the results in the form of a generalisation and analyse the best appropriate method of solution. Thus, with the recent call for mathematics teachers to adopt instructional approaches that are more flexible and catering for both girls and boys fairly (Mondoh, 1997; Changeiywo, 2001; Githua, 2002; Wachanga, 2002), the findings of the present study might prove useful in providing a starting point in this direction. The findings have shown that the PSA resulted in higher students' achievement and thus should be used in mathematics teaching at the secondary school level.

The results of this study indicate that students' gender affects their achievement in mathematics when PSA is used in mathematics instruction. Therefore, PSA is unlikely to change the trend where boys' achievement is much better than that of girls at KCSE mathematics examinations. Better girls' achievement would lead to an improvement in their representation in scientific and technological fields.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of the Study:

The findings of this study are in affirmative of a significant influence of using the PSA on gender differences in mathematics achievement. The findings are in favour of the boys taught using the PSA. The inferential statistics have revealed that there were differences between the mean scores obtained by the students in the PSA treatment groups (1 and 3) and those of the control groups (2 and 4) that were statistically significant. Therefore, the results show the influence of PSA in engendering cognitive gains. The PSA for teaching and learning the topic Commercial Arithmetics enabled the students to acquire the necessary knowledge, concepts and skills. This can be inferred from the higher mean gains obtained by the students taught using PSA as compared to those taught by the conventional methods.

The results show a positive influence on students' achievement in favour of the teaching approach. This is portrayed by the significant higher gains in the students' achievement scores in the treatment groups unlike those in the control groups. The higher mean scores in the students' achievement, in favour of the treatment groups, attest the positive influence of PSA on students' achievement in the topic Commercial Arithmetics.

Secondly, the results suggest that there was a significant influence of the teaching approaches on the students' achievement by gender. It is evident that the boys performed better than the girls. An analysis of the results buttresses the fact that both the PSA and conventional methods provided opportunities for students in co-educational schools to collaborate, support and interact together as they participated in the lesson and problem-solving group activities. The teacher serving as a facilitator structured a conducive classroom environment in which the learner organised meaning on a personal level. Hence, the PSA helped mathematics teachers to balance classroom interaction between boys and girls enabling them to give similar attention to both sexes, which led to improved achievement by both, despite the fact that boys performed slightly better than the girls.

6.2 Conclusions of the Study:

The following conclusions have been drawn from the analysis of the data presented:

a) PSA has influence on students' mathematics achievement. The PSA positively influenced the students' mathematics achievement that resulted in their autonomous learning and subsequent ownership of the lessons. Therefore, the PSA facilitates students' learning in mathematics better than the conventional teaching methods.

b) Gender influences students' achievement in mathematics when taught using the PSA.

c) The difference in the achievements level is due to PSA, otherwise both groups have basic knowledge of mathematics.

6.3 Recommendations of the Study:

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) PSA as a teaching strategy has beneficial influence on the achievement of secondary school mathematics students. Mathematics teachers should therefore enhance the use of PSA teaching strategy to address the perennial problem of underachievement, especially among secondary school students.

(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.

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

(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.

6.4 Suggestions for Further Research:

The present study suggests that the PSA can be effective in improving mathematics instruction. However, there are areas that warrant further investigation such as the following:

a) More research should be conducted to test the influence of PSA as a teaching strategy on gender differences in achievement using other topics in mathematics other than the one used in the present study.

b) Further investigation should be carried out to determine the amount of time needed to reap maximum benefits from the use of PSA as a teaching strategy on girls' achievement in mathematics.

c) Studies involving a large number of participating students, teachers and schools from other counties in Kenya to confirm whether or not the present findings hold.

d) A similar study on the influence of PSA on gender differences in achievement should be carried out in other subjects (i.e Physics, Chemistry, Biology) using both qualitative and quantitative methods of data collections approach for concurrent triangulation and corroboration.

REFERENCES

[1] Albanese, M.A. & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, 68(1): 71 – 81.

[2] Anderson, C.W. & Roth, K. J. (1989). Teaching for meaningful and self-regulated learning of science. *In Advances in Research on Teaching*, vol. 1, (pp. 265-309), JAI press.

[3] Barrows, H.S. (1996). Problem-based learning in medicine and beyond: A brief overview. New Directions for Teaching and Learning, 68:3-11.

[4] Berkel, HJMV & Dolmans, DHJM. (2006). The influence of tutoring competencies on problems, group functioning and student achievement in problem-based learning. *Med. Educ.*, 40: 730-736.

[5] Beyer, B. (1988). *Developing a Thinking Skills Program.* Boston: Allyn and Bacon.

[6] Beyer, B. (2001). What philosophy offers to the teaching of thinking. In Developing Minds, 3rd ed.: *Association for Supervision and Curriculum Development* (pp. 187-209). A. Costa. Alexandria, V.A.

[7] Biehler, R.F. & Snowman, J. (1997). *Psychology Applied to Education (8th ed.).* 373-396. Boston: Houghton Mifflin Company.

[8] Boaler, J. (1997). Reclaiming school mathematics: Teaching styles, sex and setting. *Gender and Education*, 9(3), 285-306.

[9] Boaler, J. (2002). The development of disolinary relationships: Knowledge, practice and identity in mathematics: *For the Learning of Mathematics*, 40(3), 259-281.

[10] Boone, H.N. (1988). Effects of Approach to Teach on Students Achievement, Retention and Attitude. The Ohio State University, Columbia: Unpublished Doctoral Dissertation.

[11] Borg, W.R. & Gall, M.D. (1989). *Educational Research: An Introduction (5th ed).* White plains, NY: Longman.

[12] Bransford, J., & Stein, B. (1984). *The Ideal Problem Solver*, pp. 136-170. New York: W.H. Freeman and Company.

[13] Burton, L. (1995). Moving towards a feminist epistemology of mathematics. In P. Roges & G. Kaiser (Eds). *Equity in Mathematics Education: Influences of Feminism and Culture* (pp. 209-225). London: The Falmer Press.

[14] Campbell, B.P. (1995). Redefining the girl problem in mathematics. In W. G. Secada, E. Fennema & L.B. Adajian (Eds.), *New Direction for Equality in Mathematics Education,* (pp. 259-275). New York, NY: Cambridge University Press.

[15] Caplan, J.B. & Caplan, P.J. (2005). The perseverative search for sex differences in mathematics abilities. In A.M. Gallagher and J. C. Kaufman (eds.). *Gender Differences in Mathematics: An Integrative Psychological Approach.* Campridge: University press.

[16] Carpenter, T.P. (1998). Teaching as Problem solving. In R.I. Charles and E. A. Silver (Eds.). *The Teaching and Assessing of Mathematical Problem Solving,* (pp. 187-202). Reston, Virginia: NCTM.

[17] Carr, M., & Jessup, D. L. (1997). Gender differences in first grade mathematics strategy use: Social and metacognitive influences. *Journal of Personality and social Psychology*, 89: 318 - 328.

[18] Changeiywo, J.M. (2001). Gender perspectives in science and technology in Kenya. *Journal of Education and Human resources*, 1 (1): 14 –28.

[19] Chin, C. & Chia, L.G. (2004). Problem Based Learning using students' questions to drive knowledge construction, *Science Education,* 88(5): 707-727.

[20] Cook, M. (2001). The thinking arena for Problem-Solving. *In Developing Minds, 3rd ed.* A Costa. Alexandria, V.A: Association for Supervision and Curriculum Development.

[21] Cooper, R. & Robinson, P. (2002). *Small-Group Instruction in Science, Mathematics, Engineering and Technology (SMET) Disciplines*, (pp. 234-276). Dominguez Hills: California State University.

[22] Costello, J. (1991). *Teaching and Learning Mathematics, 11-16.* New York: Routledge.

[23] Dart, B.C., Burnett, P.C., & Purdie, N.M. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning, *J. Educ. Res.,* 93(4): 262-270.

[24] Dolmans, DGJM, Wolfhagen IHAP, Van der Vleuten, CPM, Wijnen WHFM. (2001). Solving problem with group work in problem-based learning: Hold on to the philosophy. *Medical Education,* 35:884-889.

[25] Dolmans, DHJM & Schmidt, HG. (2006). What do we know about Cognitive and Motivational effects of small group tutorials in problem-based learning? *Advanced Health Science Education,* 11: 312-336.

[26] Duch, B. (1995). Problem-based learning in physics: the power of students teaching students. *About Teaching*, 47, 6-7.

[27] Duffy, T.M. & Johassen, D.H. (1992). *Constructivism: New Implications for Instructional Technology: A Conversation.* (pp. 89-112, 159-197). New Jersey: Lawrence Erlaum Associates.

[28] Education Office Vihiga (2010). Vihiga secondary schools statistics, (pp. 17-30). Unpublished document.

[29] Eng, C. S. (2001). *Problem Based Learning-Educational Tool or Philosophy.* University of Newcastle, Australia. [online] Available: http://edweb.sdsu.edu/clrit/leraning tree/PBL/PBLadvantage.html.

[30] Eshiwani, G.S. (1975). Sex differences in the learning of mathematics among Kenya high school students. Paper for staff seminar at the Bureau of Educational Research, University of Nairobi, May, 21st.

[31] Eylon, B., & Linn, M. C. (1988). Learning and instruction: an examination of four research perspectives in science education. *Review of Educational Research,* 58: 251 - 301.

[32] Farrel, J.P. (1993). International lessons for school effectiveness: The view from developed world. In J.P. Farrel and J.B. Oliveira (Eds.). *Teachers in Developing Countries: Improving Effectiveness and Managing Costs,* (pp. 28–30). Washington D.C.: World Bank.

[33] Fraenkel, J.R. & Warren, N.E. (1990). *How to Design and Evaluate Research in Education,* (pp. 230 – 270). New York, NY: McGraw – Hill Inc.

[34] Fuson, K.C., William, M. C., & Jane, V.D. (2000). Achievement results for second and third graders using the standard-based curriculum everyday mathematics. *Journal for Research in Mathematics Education,* 31: 277-295.

[35] Gall, M.D., Borg, W.R. & Gall, J.P. (1996*). Education Research: An Introduction (6th ed.).* NY: Longman Publishers.

[36] Gallagher, S. A., Stephen, W. J., Sher, B. T. & Workman, D. (1999). Implementing Problem Based Learning in science classrooms. *School Science and Mathematics,* 95(3), 136-146.

[37] Geary, D. C., Hoard, M. K. (2000). Sex differences in spatial cognition, computational fluency and arithmetic reasoning. *Journal of Experimental Child Psychology*, 77:337-353.

[38] Gibbon, B.S. & Herman, J. (1997). *True and Quasi-Experimental Designs.* Clearing House on Assessment and Evaluation, Washington, D.C. ERIC.

[39] Githua, B.N. (2001). Factors Affecting Teaching and Learning of Mathematics in Kenya Secondary Schools. Unpublished Paper Presented at Nakuru Sub-county Science and Mathematics Seminar, Nakuru High School, 9th – 12th April.

[40] Githua, B.N. (2002). Factors Related to the Motivation to Learn Mathematics. Egerton University, Kenya: Unpublished Doctoral thesis.

[41] Greeno, J.G., Collins, A.M., & Resnick, L. (1996). Cognition and learning. In: Caffee RC, Berliner DC (eds.). *Handbook of Educational Psychology,* pp. 15-46. New York: Macmillan.

[42] Groves, M. (2005). Problem-based learning and learning approach: Is there a relationship? Advanced Health Science Education, 10(4): 315-326.

[43] Hiebert, J., & Weirner, D. (1993). Instructional Task, Classroom Discourse and Students' Learning in second grade. *American Educational Research Journal,* 30:393-425.

[44] Johnson, D.W. & Johnson, R.T. (1995). *Reducing School Violence through Conflict Resolution*, pp. 26-28. Alexandria VA, USA: Association of Supervision and Curriculum Development (ASCD).

[45] Kelly, R.R., Lang, H.G. & Pagliaro, C.M. (2003). Mathematics word problem solving for deaf students: A survey of perceptions and practices in grade 6 – 12. *Journal of Deaf Studies and Deaf Education,* 8 (2): 104 –119.

[46] Kenya Institute of Curriculum Development (2002). *The Secondary School Syllabus*, Vol. *2*. Nairobi. KICD.

[47] Kenya Institute of Curriculum Development (2006). *The Secondary School Syllabus*, Vol. 2: 13-14, 28-29. Nairobi: KICD.

[48] Kenya National Examination Council (2007). *2006 Examination Report*, Vol 1:14-20. Nairobi: KNEC.

[49] Kenya National Examination Council (2008). *2007 KCSE Examination Candidates Performance*, Vol 1 :15-21. Nairobi: KNEC.

[50] Kenya National Examination Council (2009). *2008 KCSE Examination Candidates Performance,* Vol 1 : 26-32. Nairobi: KNEC.

[51] Kenya National Examination Council (2010). *2009 KCSE Examination Candidates Performance,* Vol 1 : 30-37. Nairobi: KNEC.

[52] Kimura, D. (2002). Sex differences in the brain. *Scientific American Special Edition*. 12: 32 – 37.

[53] Kirembu, J.K. (1991). A Study of Selected Factors Related to Performance in Mathematics among Form Three Students in Kirinyaga Sub-county, Kenya. Kenyatta University: Unpublished M.Ed. thesis.

[54] Lester, F., & Charles, R. I. (2003). *Teaching mathematics through problem solving,* (pp. 123-151). Reston, VA: National Council for Teachers of Mathematics.

International Journal of Novel Research in Education and Learning
Vol. 5, Issue 2, pp: (59-82), Month: March - April 2018, Available at: www.noveltyjournals.com

[55] Lochhead, J. & Zietsman, A. (2001). What is Problem Solving? In Developing Minds, 3rd ed. A. Costa. *Association for Supervision and Curriculum Development,* Alexandria VA

[56] Lucas, A. F.(1990). Using Psychological Models to Understand Student Motivation.

[57] Major, C.H., Baden, M.S., & Mackinnon, M. (2000). Issues in Problem Based Learning: A Message from Guest Editors. *Journal on Excellence in College Teaching,* 11(3): 117- 125.

[58] Makau, B.M. & Coombe, C. (1994). *Teachers Role and Motivation in Sub-Saharan Africa: Making Practical Improvement*s. London: Common Wealth Secretariat.

[59] Mangle, S. K. (2008). *Advanced educational Psychology,* (2nd ed, pp 378-380). Prentice Hall Students.

[60] Margetson, D. (2008). Current educational reform and the significance of problem-based learning. *Stud. Higher Educ.,* 19(1): 5-19.

[61] Maritim, E.K. (1984). Observed Classroom interaction and academic performance of primary school pupils. *Kenya Journal of Education,* 1 (1): 1-21.

[62] Mayya, S.S., Rao, A.K., & Ramnarayan, K. (2004). Learning approaches, learning difficulties and academic performance of undergraduate students of physiotherapy. *Internet J. Allied Health Sci. Practice,* 2(4): 1-6.

[63] Mondoh, H.O. & Yadav, P.S. (1998). Characteristics of effective primary school mathematics teachers: The case of Varanasi and Nakuru Sub-countys, Kenya. *Egerton Journal,* 2 (1): 111 – 122

[64] Mondoh, H.O. (1995). An Investigation of Teaching Effectiveness and Students' Achievement in Mathematics. Banaras Hindu University: Unpublished Doctoral Thesis.

[65] Mondoh, H.O. (1997). Girls' poor performance in mathematics: A critical review. *Journal of Education and Human Resources,* 1(1): 170 –171.

[66] Mondoh, H.O. (2000). Individual differences in mathematics classrooms. Unpublished training paper presented at a workshop held at Menengai High School, Nakuru of 19th April 2000.

[67] Mugenda, O.M. & Mugenda, A.G. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi: African Centre for Technology Studies (ACTS).

[68] Novak, J.D. & Gowin, D.B. (1984). *Learning how to Learn*. New York: Cambridge university press.

[69] Novak, J.D. (1998). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations.* Mawah, NJ: Lawrence Erlbaum.

[70] O'Connor, P.S., Schiering, M, Hayes, B., & Serrano, B. (2004). Pedagogical and Parental influences in Mathematic Achievement by gender among selected European countries from TIMSS-R study. *In Proceedings of the IRC-2004 vol. II (ed)* C. Papanastasiou, (Cyprus University, Nicosia,) pp. 69-84.

[71] Okere, M.O. (1996). *Physics Education.* Egerton University: Education Media Centre.

[72] Okerere, S. C. (2006). Effect of prior knowledge of implementing of mathematics tasks/concepts to career types and gender on students' achievement, interest and retention. In U. Nzewi (Ed) STAN *Proceeedings of the 47th Annual Conference,* 253-259.

[73] Okigbo, E. C. & Osuafor, A. M. (2008). Effect of using Mathematicacs Laboratory in Teaching Mathematics on the Achievement of Mathematics, *Educational Research and Review,* 3(8): 257-261.

[74] Polya, G. (1973). *How to Solve it. (2nd Ed).* Princeton N.J.: Princeton University Press.

[75] Ramsden, P. & Entwistle, N. (2010). Effects of academic departments on students' approaches to studying. *Bri. J. Educ. Psychol.,* 51(3): 368-383).

[76] Ramsden, P. (1995). *Learning to Teach in Higher Education,* 2nd ed., pp. 358-361. London: Routledge.

[77] Rhem, J. (1998). Problem-based learning: An introduction. The National Teaching & Learning Forum, 8(1). Available online at http://www.ntlf. Com/html/pi/9812/pbl 1.htm.

[78] Ridgway, J., Judith, S. Z. Mark, N. H., & Diana, L. (2002). Student attainment in the connected Mathematics curriculum. In Sharon S. & Denese T. (Eds). *Standards-oriented school mathematics curricula: What are they? What do students learn?* (pp. 31-42). Mahwah, NJ: Erlbaum.

[79] Rodd, M. & Bartholomew, H. (2006). Invisible and special: Young women's experiences as undergraduate mathematics students. *Gender and Education*, 18(1), 35-50.

[80] Rogers, P. (1995). Putting theory into practice. In P. Rogers & G. Kaiser (Eds.). Equity in mathematics education: *Influences of Feminism and Culture*, (pp. 187-209). London: The Falmer press.

[81] Roh, K. H. (2003). Problem-Based Learning in Mathematics-*ERIC clearing house for Science, Mathematics and Environmental Education*.[online] Available:http://www.ericdigests.og/2004-3/math.html.

[82] Romberg, T.A. & Shafer, M. (2002). Mathematics in context: Preliminary evidence about student outcome. In Sharon S. & Denese T. (Eds), *Standards-oriented school mathematics curricula: What are they? What do students learn?* (pp. 1-22). Mahwah, NJ: Erlbaum.

[83] Sadker, M. & Sadker, D. (1986). Sexism in the classroom: From grade school to graduate school. *Phi Delta Kappan*, 67, 512-515.

[84] Samuelsson, J. (2008). The impact of different teaching methods on students' arithmetic and self-regulated learning skill. *Education Psychology in Practice*, 24(3):237-250.

[85] Sanders, W.B. & Pihney, T.K. (1979). *The Conduct of Social Research*, (pp. 161-183). Chicago, CA: Holt, Rinehart and Winston, Inc.

[86] Sanga, P.M. (1982). Analysis of Classroom Interaction Patterns of Kenyan Secondary School Chemistry Teachers and their Behaviours. University of Nairobi: Unpublished M.Ed. thesis.

[87] Schmidt, H.G. (1993). Foundations of Problem-Based Learning: Some explanatory notes, *Medical Education*, 27:422-434.

[88] Scott-Hodgetts, R. (1986). Girls and mathematics: The negative implications of success. In L. Burton (Ed.), *Girls into Mathematics Can Go*, (pp. 61-76). London: Rinehart & Winstone.

[89] Sezgin, S.G. (2009). The effects of problem-based learning on teachers' achievement, approaches and attitudes towards learning physics. *International Journal of the Physical Sciences*, 5(6): 711-723.

[90] Sharma, R.N. (2002). *Methodology of Educational Research*. Delhi: Surjeet Publications.

[91] Shimazoe, J.K. & Aldrich, H. (2010). Group can be gratifying: Understanding and overcoming resistance to cooperating learning. *College Teaching*, 58: 52-57.

[92] Silva, E. (2009). Measuring skills for 21st Century Learning. *Phi Delta Kappan*,90 (2). 272- 275.

[93] SMASSE (2003). Instrument for internal monitoring and evaluation (pp. 8 - 45). Nairobi, Kenya

[94] Sprigler, D. M. & Alsup, J. K. (2003). An analysis of gender and the mathematical reasoning ability. *Education*, Vol. 123(4): 331-342.

[95] Stigler, J. W., & Hierbert, James (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*, (pp. 127-146). New York: The Free Press.

[96] Sungur, S., Tekkaya, C., & Geban, O. (2006). Improving achievement through Problem-based learning, *Journal of Biology Education*, 40(4):155-160.

[97] Tick, A. (2007). Application of Problem Based Learning in classroom activities and multimedia. *5th Slovakian Hungarian Joint Symposium on applied machine intelligent and informatics*. [online] Available:http://bmf.hu/ conferences/sami2007/36_Andrea.pdf

[98] Trigwell, K., Prosser, M., & Waterhouse, F. (2000). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Educ.*, 37(1): 57-70.

[99] Trobridge, W.L. & Bybee, R.W. (2004). *Teaching Secondary Science: Strategies for Developing Scientific Literacy*, 2nd ed., pp. 230-242. New Jersey: Pearson Education Inc.

[100] Wachanga, S.W. (2002). Effects of Co-operative Class Experiment Teaching Method on Secondary School Students' Motivation and Achievement in Chemistry. Egerton University: Unpublished Doctoral thesis.

[101] Walker, J.T. & Lofton, s. P. (2003). Effect of Problem Based Learning Curriculum on Students' perceptions of Self-directed Learning. *Issues in Educational Research*, 13(6): 120-125.

[102] Wasike, D.W. (2003). Effect of a Socialised Mathematical Language Module on Students' Understanding of Mathematics and their Perception of the Learning Environment. Egerton University: Unpublished M.Ed. thesis.

[103] Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values, and tasks perceptions according to gender and domain in 7th – 11th grade Australian students. *Child Development*, 75:1556-1574.

[104] Weber, K. (2008). Mathematicians' validation of proofs. *Journal for Research in Mathematics Education*, 39 (4), 431-459.

[105] Weiner, G. (1978). "Sex Differences in Mathematical Performance: A Review of Research and Possible Action." In R. Deem (Ed.), *Women and Schooling.* London: Routledge & Kegan Paul, pp. 1-53.

[106] Wekesa, W.E. (2003). Effect of a Computer-Based Instruction Module on Students' Achievement, Perception of Classroom Environment and Attitude towards Biology in Nakuru Sub-county, Kenya. Egerton University: Unpublished M.Ed. thesis.

[107] Wood, T., & Sellars P. (1997). Deepening the Analysis: Longitudinal Assessment of a Problem-centred mathematics Program. *Journal for Research in Mathematics Education*, 28: 163-186.

[108] Yuzhi, W. (2003). Using Problem Based Learning and Teaching Analytical Chemistry. *The China Papers*, 3:28-33.

[109] Zechariah, E. (2010). The Effects of Co-operative learning on Students' mathematics Achievement and attitudes toward mathematics. *Journal of Social Sciences*, 6 (2). 272- 275.