Educational Research and Reviews Vol. 6(12), pp. 726-745, 25 September, 2011
Available online at http://www.academicjournals.org/ERR
ISSN 1990-3839 ©2011 Academic Journals

Full Length Research Paper

Effects of cooperative learning approach on biology mean achievement scores of secondary school students' in Machakos District, Kenya

Daniel Ngaru Muraya[1] and Githui Kimamo[2]*

[1]Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), P. O. Box 24214-00502, Nairobi, Kenya.
[2]Catholic University of Eastern Africa, Kenya.

Accepted 8 September, 2011

Performance in Biology at secondary school level in Kenya remains poor and one reason is the teaching approach adopted by teachers with teacher-centered approaches being pre-dominant. This study sought to determine the effect of cooperative learning approach on mean achievement scores in Biology of secondary school students. Solomon-four-non-equivalent-control-group design was used and the target population comprised 183 form two students in four secondary schools. Students were taught one Biology topic for five weeks and cooperative learning approach was used in experimental groups while the regular teaching method was used in control groups. Pre-test was administered before treatment and a post-test after treatment. A Biology Achievement Test was used to measure students' achievement and it attained a reliability coefficient of 0.84 (N=59) at pilot testing. Data was analyzed using t-tests, ANOVA and ANCOVA and hypotheses were accepted or rejected at significant level of P≤0.05. Cooperative learning approach resulted in significantly higher mean achievement scores compared to regular teaching method and gender had no significant influence on achievement. It was concluded that cooperative learning approach is an effective teaching approach which Biology teachers should be encouraged to use.

Key words: Cooperative learning approach, student achievement, Biology, effects.

INTRODUCTION

The current long-term development policy of the Government of Kenya (GoK) is to transform the country into a newly industrialized, middle-income economy providing a high quality life to all its citizens by the year 2030 (GoK, 2007). One of the strategies towards this goal is to provide its citizens with globally competitive quality education, training and research for development and enhanced individual well-being as it is acknowledged that human resource is central to the country attaining its goals of industrial development and technological advancement (UNESCO, 2004; GoK, 2005; GoK, 2007). The GoK further intends to have international ranking for her children's achievement in Mathematics and Science, as these subjects are critical for socio-economic development of a country (GoK, 2007; Gödek, 2004; Ogbo, 2004). Another strategy is to increase the proportion of all Kenya students studying science related courses at public university to 50% of the total public university student enrolment by the year 2010 (GoK, 2005). These policy statements underline the commitment of the GoK to improve the quality of science education for socio-economic development of the country.

The education system in Kenya since 1985 is structured on the 8-4-4 model with eight years of primary schooling followed by four years of secondary education and at least four years of a bachelor degree program at university (MoE, 2001). At the secondary school education cycle, students take a minimum of seven and a maximum of nine subjects to meet the entry requirement for the Kenya Certificate of Secondary Education (KCSE) examination which is offered by the Kenya National Examination Council (KNEC) as stipulated in their syllabuses and regulations (KNEC, 2005). Based on marks

*Corresponding author. E-mail: gmkimamo@yahoo.com. Tel: +254-722851104.

marks scored by a candidate in a subject, a grade is awarded on a 12 point grading scale: A, A-, B+, B, B-,C+, C, C-, D+, D, D- and E. Grade A is the highest grade scoring 12 points while grade E is the lowest grade, scoring 1 point (KNEC, 2005). In addition, grades A and A- are indicated as good which implies that a student who attains these grades at KCSE has very good mastery of the subject matter. Grades B+, B and B- are indicated as good and likewise a student who attains these grades is regarded as having good mastery of the subject matter. On the other hand, grades D and D- are indicated as being weak while grade E is indicated as poor, which implies that a student who attains these grades has weak and poor mastery of the subject matter, respectively (KNEC, 2005). Therefore, students who attain grades D, D- and E are regarded as having failed to attain the expected basic mastery of the subject content matter. This has implications on future career prospects of the students due to the fact that the grades that a student attains in different subjects at KCSE examination determine admission for further education and training at universities and other tertiary institutes.

The Programme for International Student Assessment (PISA) has noted that the performance of a country's students in science subjects have implications for the part which that country will play in tomorrow's advanced technology sector, and for its general international competitiveness (PISA, 2003). This report has further emphasized on the critical role of science subjects in the socio-economic development of a country. Biology is one of the science subjects that are offered at the secondary school education cycle in Kenya (KIE, 2002). The knowledge of biology contributes to scientific literacy so that people can understand the world around them and enable them to make informed choices about their health care, their environment and the society in which they live (Karen, 2008).

According to the KIE (2002), the study of biology aims at equipping the learner with knowledge, skills and attitudes that are necessary for controlling and preserving the environment; enables the learner to appreciate humans as part of the broader community of living organisms; is a foundation for careers in health, agriculture, environment and education; and is the precursor of biotechnology which is a tool for industrial and technological development. KIE which is the national curriculum development and research centre in Kenya has identified objectives that a learner should acquire after going through the four year Biology course at the secondary school education cycle (KIE, 2002). These objectives include the ability to communicate biological information in a precise, clear and logical manner; apply the knowledge gained to improve and maintain the health of the individual, family and the community; develop positive attitudes and interest towards Biology and the relevant practical skills; create awareness of the value of cooperation in solving problems; and acquire a firm foundation of relevant knowledge, skills and attitudes for further education and training in related scientific fields. These objectives are a further recognition of the critical role that the knowledge of Biology contributes towards the socio-economic development of a country. The knowledge of Genetics which is a branch of Biology has revolutionalised determination of paternity disputes and identity of serious crime culprits with precision and certainty through Deoxyribo-Nucleic Acid (DNA) sequencing and profiling (Institute of Biology, 2007). Biology has contributed to the development of new and better drugs and vaccines against many human and animal diseases such as malaria, measles, polio, riderpest and it has also contributed towards conservation of the environment and endangered species. Biology lays the foundation for careers in agriculture, which is the engine for economic growth in Kenya contributing 60% of foreign exchange earnings and providing employment to over 70% of the population (GoK, 2003). Through the knowledge of Biology, researchers have been able to develop high yielding, disease resistant and fast maturing food crops and animals to meet the food requirements of an ever increasing world population. Biology is a prerequisite subject for admission into courses in the health profession such as Human and Veterinary Medicine, Pharmacy and Dentistry among others.

Despite the importance of the knowledge of biology for socio-economic development of a country, performance in Biology at KCSE which is offered by KNEC has been poor over the years (MoE, 2005). Out of the 201,991 candidates who sat for KCSE Biology in 2004 nationally, only 12.03% attained the high quality grades B+ to A while 36.67% of the candidates attained the low quality grades D to E (KNEC, 2005). This implies that more than a third of the candidates who sat for KCSE Biology in that year failed to meet the expected mastery of the subject matter and this locked them out of careers where Biology is a prerequisite subject. In 2005 when 236,262 candidates were entered for Biology, only 7.7% attained grades B+ to A while 43.61% attained grades D to E (KNEC, 2006). In 2006 only 6.12% of the candidates attained grades B+ to A while 49.64% which was almost half the candidature in that year attained grades D to E and this was below the expected basic mastery of the subject (KNEC, 2007). The performance was relatively the same in 2007 when only 8.79% of the candidates attained grades B+ to A while 40.76% attained grades D to E (KNEC, 2008). For the years under review, more than a third of the candidates in Biology attained grades below the stipulated basic mastery of the subject matter.

In Machakos District, achievement in Biology at KCSE has been low and a similar trend of poor performance which was lower than the national average is observed for the years under review. In 2004 for example, 7.43% of the candidates who sat for Biology at KCSE in Machakos District attained grades A to B+ while 46.98% attained

grades D to E (KNEC, 2005). For 2005 the figures were 4.45 and 51.94% for grades A to B+ and D to E, respectively (KNEC, 2006). The year 2006 registered the lowest performance for the years under review with 3.36 and 61.17% of the candidates attaining grades A to B+ and D to E, respectively (KNEC, 2007). This implies that close to two-thirds of the candidates who sat for Biology at KCSE in Machakos District in 2006 did not attain the expected basic mastery of the subject matter. For 2007 the figures were 5.46 and 49.03% for grades A to B+ and D to E, respectively (KNEC, 2008). From these results, performance in Biology at KCSE in Machakos District has been poor and below the national average. Almost half of the candidates who sat for biology at KCSE in Machakos District for the years under review failed to attain the expected subject mastery level which locked them out of careers where Biology is a prerequisite subject.

Learning achievement was adopted as a key indicator of the quality of education during the World Conference on Education for All (EFA) in Jomtien, Thailand, (UNESCO, 2000). Since achievement in Biology at KCSE in Kenya has been consistently low over the years, this is an indicator of low quality Biology education. The performance in Biology at KCSE for the years under review clearly indicates that a large proportion of students who leave secondary school education cycle at form four in Kenya do not attain the basic subject mastery level of the secondary school Biology course. For Machakos District in particular, performance In Biology at KCSE has remained consistently poor and below the national average for the years under review and almost half of the students who sat for Biology at KCSE for the years under review failed to attain the basic mastery of the subject matter. It is imperative to note that unless this trend is reversed, the prospects of attaining the goal of Kenya Vision 2030 will be in jeopardy.

Many factors contribute to poor performance of science subjects at KCSE. These factors include: Student attitude towards the subjects which they perceive as difficult; inappropriate teaching approaches that are teacher rather than student centred; inadequate mastery of teaching subject content by some teachers; inadequate teaching and learning resources such as text books and laboratory equipment and apparatus; poor terms and conditions of service for teachers; and heavy teaching loads among others (Kibe, JICA-Kenya, personal communication). He further notes that the teaching approach employed by a teacher is one of the important explanations of poor performance in science subjects at KCSE. Teacher centred teaching approaches are dominant at the secondary school level where the teacher presents information to students in a lecture and students complete assignments out of class and later take an examination to demonstrate their degree of understanding and retention of the subject matter (Kolawole, 2008). The lecture method which is predominant in our classrooms does not stimulate students' innovations, inquiry and scientific thinking but rather encourages students to cram facts which are easily forgotten (Adeyemi, 2008). In Kenya, secondary school teacher training combines teaching methodology and teaching subject content mastery and under this system both academic and methodology suffer from an overburdened programme (MoE, 2005). This may imply that the teachers are not adequately prepared on teaching approaches which may in turn explain the low achievement in Biology at KCSE. In order to address the low achievement in Biology at KCSE in Kenya, Biology teachers need to be exposed to appropriate teaching and learning approaches that are learner centred rather than teacher centred. The learner centred teaching and learning approaches actively engage the learner in the learning process for effective mastery of the subject content matter and promotes a positive attitude towards the subject. To improve academic achievement, the teaching approaches adopted by a teacher should make learning more learner-centred so as to promote imaginative, critical and creative skills in the learners resulting in better achievement of instructional objectives (Ministry of Education Science and Technology, 2001).

Teaching and learning approaches

Brown et al. (1982) defines teaching and learning as an attempt to help someone acquire or change some knowledge, skill or attitude. Ayot et al. (1992) further define teaching and learning as a process where one person, the teacher intentionally passes information to another person, the learner. Therefore the goal of teaching is to bring about desirable learning in students. In this process, the learner is expected to receive information, understand it and use it later when the need arises. For effective teaching and learning to occur, the teacher must use an effective approach of conveying the information to the learner (Brown et al., 1982). He further notes that the way a teacher teaches is important in that with the right methods and techniques, students can grasp concepts and ideas while poor methods and techniques frustrate students and minimize their chances of success. It emerges from the fore-going discussion that for effective teaching and learning the approach adopted by a teacher is paramount and teachers should therefore have a choice of effective teaching and learning approaches for effective learning to occur.

Arends (1997) notes that many teaching and learning approaches have been created and studied by educational researchers, classroom teachers, psychologists, industrial trainers and philosophers. He further notes that a teaching and learning approach has four defining attributes: a coherent theoretical rationale made explicit by its creators or developers; a point of view about what and how students learn; specific teaching behaviours that make the approach to work; and,

required classroom structures for bringing about intended outcomes. Arising out of this, teaching and learning approaches are classified according to their instructional goals, their syntaxes (sequential patterns) and the nature of their learning environments. Arends (1997) further notes that a teaching and learning approach syntax refers to the overall flow or sequence of steps that a lesson usually follows and it specifies what kinds of teacher and student actions are required, the order in which these actions normally occur, and the particular task demands placed on students. Each teaching and learning approach employs different learning environment and management system and places different demands on the learner, on the physical space, and on the classroom social system. He further classifies teaching and learning approaches into four types: direct instruction, problem-based instruction, cooperative learning and discussion. Direct instruction is based on ideas from behavioural psychology and social learning theory. It is designed to promote student learning of well-structured procedural and declarative knowledge that can be taught in a step-by-step fashion and requires a tightly structured learning environment. Problem-based instruction is based on cognitive psychology and constructivist perspectives about learning and is an effective approach for teaching higher-level thinking processes and helping students construct their own knowledge about the social and physical world around them. Discussion as a teaching and learning approach cuts across the other teaching approaches and therefore it is used in conjunction with another teaching and learning approach. For example discussion can occur in small groups during cooperative learning or between a teacher and students during a problem-based lesson. Cooperative learning approach has its foundation on social-constructivist perspectives of learning. In this approach, the classroom environment is characterized by cooperative tasks and incentive structures and by small group activity. It can be used to teach complex academic materials and can help teachers accomplish important social learning and human relations goals. It is therefore possible to distinguish and select different teaching and learning approaches that are appropriate for attaining particular objectives in a teaching and learning situation. Teaching and learning approaches that are student-centred promote more learning in that learning is more likely to be effective where a student plays a proactive role in the learning process (PISA, 2000).

Effective teaching and learning approaches in science

The American Association for the Advancement of Science (AAAS) (1989) report advices that: “the collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom. Scientists and engineers work mostly in groups and less often as isolated investigators. Similarly, students should gain experience sharing responsibility for learning with each other”.

This statement underlines the importance of actively involving students in science lessons that incorporates group activities for greater interaction and discussions among the students. The knowledge of how teaching and learning approaches affect students’ learning may help science teachers to select teaching and learning approaches that improve teaching quality, effectiveness, and accountability to learners and the public (Wachanga and Mwangi, 2004). According to McDowell (2001), research on learning no longer supports a transmissive style of lecturing as it has been found that learning through memorisation and reproduction does not result in knowledge that can be used to reason and to solve problems in new situations. He further notes that what the student does is more important in determining what is learned than what the teacher does. Thus, the teacher's role is not to lecture in an exclusively transmissive way, but to encourage active participation, dialogue and interaction by students with course materials and with each other. Students learn by interacting with and transforming received information so as to own it and make it personally meaningful which leads to powerful understanding and useful knowledge. Effandi and Zanaton, (2007) have noted that teachers should have the knowledge of how students learn science and how best to teach and that effort should be taken now to direct the presentation of science lessons away from the traditional methods to a more student centred approach. Similarly Wambugu, and Changeiywo, (2008), note that the teaching approach that a teacher adopts is one factor that may affect student’s achievement and therefore use of an appropriate teaching approach is critical to the successful teaching and learning of science. Learning is facilitated by a range of tasks that involve students in active processing, such as questioning, explaining and discussion.

According to NRC (1995), effective teaching is at the heart of science education and good teachers of science create environments in which they and their students work together as active learners. The need for effective teaching and learning of science at secondary school level in Kenya as a means of achieving industrial and technological advancement is a widely recognized and accepted fact but despite this recognition, performance in science subjects at KCSE has consistently remained poor over the years (Wachanga and Mwangi, 2004). There is a relationship between the teaching and learning approach and achievement in science subjects. Studies on teaching and learning approaches in science subjects indicate that cooperative learning approach increases student’s academic achievement in science subjects more than traditional teaching and learning approaches (Wachanga and Mwangi, 2004; Armstrong et al., 2007;

Ho et al., 2007; Kolawole, 2008). Given the possible link between science achievement and teaching and learning approaches, biology teachers should adopt teaching and learning approaches that can improve student achievement as the focal point of reversing the current trend of low achievement in biology at KCSE.

Cooperative learning approach

The UNESCO-EFA Global Monitoring Report (2005) notes that; "practitioners broadly agree that teacher-dominated pedagogy where students are placed in a passive role is undesirable, yet such is the norm in the vast majority of classrooms in Sub-Sahara Africa". The report further notes that there is consensus on the desirability of a participatory, interactive, learner-centred, active pedagogy that is characterized by cooperative learning. According to Johnson et al. (1994), cooperative learning is the structuring of small groups so that students work together to maximize their own and each other's learning. Agashe (2004) notes that there has been great interest on the effects of social interaction on students' achievement, and cooperative learning has been found effective across various academic levels and subjects. Cooperative learning refers to a method of instruction whereby students work together in groups to reach common goals. In contrast to the conventional method where students work individually or competitively, with cooperative learning students help one another and benefit from sharing ideas. It is the instructional use of small groups so that students work together to maximize classroom learning and accomplish shared learning goals (Liang et al., 2005). Agashe (2004) further notes that cooperative learning is a teaching approach involving students' participation in group learning that emphasizes positive interaction. It is a strategy by which small teams, each with students of different levels of ability, are engaged in learning activities to improve their understanding of a subject. The participation of every student in the group and cooperation among group members is considered important. The students are rewarded for their individual and collective efforts.

Aronson (2002) has noted that cooperative learning approach encourages listening, engagement and empathy by giving each member of the group an essential part to play in the academic activity. Group members must work together as a team to accomplish a common goal and each person depends on all the others. No student can achieve his or her individual goal of learning the material or getting a good grade unless everyone works together as a team. Group goals and individual goals complement and bolster each other. This cooperation by design facilitates interaction among all students in the class, leading them to come to value each other as contributors to their common task. Effandi and Zanaton (2007) further notes that cooperative learning represents a shift in the educational paradigm from teacher-centred approach to a more student-centred learning in small groups and it creates excellent opportunities for students to engage in problem solving with the help of their group members. There is a difference between simply having work in a group and structuring groups of students to work cooperatively. Putting students into groups does not necessarily gain a cooperative relationship; it has to be structured and managed by a teacher. Therefore cooperative learning has specific distinctive elements that distinguish it from other teaching and learning approaches. Johnson et al (1994) proposed five essential elements that are necessary to construct positive, effective cooperative group learning situations: Positive interdependence; face-to-face promotive interaction; individual and group accountability; interpersonal and small-group skills; and group processing or evaluation.

Positive interdependence

In traditional classrooms, where competition is emphasized, students experience negative interdependence, competing with one another for educational resources and academic recognition. Competition encourages better students to hoard knowledge and to celebrate their successes at the expense of other students. In cooperative learning classrooms, students work together to ensure the success of each student. Positive interdependence teaches students that school life for each one of them is enhanced when everyone succeeds. Students must see that their success is dependent on the contributions, inclusion, and success of the other students in the group. Creating positive interdependence requires a teacher to craft tasks that require the insights and efforts of more than one person. Positive interdependence can also be promoted by linking the grades given on an assignment not just to an individual performance on the test but to the performance of the other group members.

Face to face promotive interaction

In cooperative learning situations, students interact, assist one another with learning tasks, and promote one another's success. The small group setting allows students to work directly with one another, to share opinions and ideas, to come to common understandings, and to work as a team to ensure each member's success and acceptance. Students must have time and opportunity to exchange ideas orally and discuss the concepts at hand. This occurs as structured time for discussion during class, often with the discussion scaffolded by a series of questions or controversies posed

by the teacher. To ensure student discussion, the groups may be required to report to the rest of the class and have individual students make summaries of the discussion. In addition, promotive interaction can be achieved through assigning, each student in the group a specific role such as facilitator, recorder, time keeper etc. This provides every member of the group an entry point for participation and begins to generate individual responsibility within the group.

Individual and group accountability

In cooperative learning settings, each student is held accountable for his or her own academic progress and task completion, apart from the accomplishments of the group as a whole. Individuals may also be held accountable by means of grades based on their academic achievement. Students must be accountable both for contributing their share of the work as well as for the group reaching its common goal. The aspiration of cooperative learning is to enable all students to benefit from the insights and skills of their colleagues and thus each improve their own learning. Individual and group accountability is achieved by grading students both on their individual work and on the work of the group, for example, both on an individual test and on a group performance.

Interpersonal and small group skills

Cooperative learning offers students a chance to develop the interpersonal skills needed to succeed at school, work, and within the community. Examples of cooperative skills include: Active listening to all members of the group; allowing all members of the group to verbally participate in discussion; being critical yet supportive of alternative views; maintaining opinions until convincing contrary evidence is provided; learning how to ask clarifying questions; effective communication; understanding and appreciation of others; decision making; problem solving; conflict resolution and compromise among others.

Group processing or evaluation

Groups of students need to evaluate and discuss how well they are meeting their goals, what actions help their group, and what actions seem to hurt group interaction. They may articulate these evaluations during class discussion or provide the teacher with written progress reports. Students should also have a way of alerting the teacher to group problems. The teacher must develop plans for engaging students in problem solving and conflict resolution. Students must have the opportunity to discuss how the work of the group is going, what has been successful, and what could be improved. Engaging in group processing enable students to improve their skills in working cooperatively, learn to address difficulties or tensions within the group, and experience the process of conflict resolution that are essential in any workplace.

Students teams achievement division (STAD) model of cooperative learning approach

Several models of cooperative learning have been developed by different educators. Slavin (1995) identified students teams achievement divisions (STAD), teams-games tournament (TGT) and Jigsaw cooperative learning models. Arends (1997) also identified STAD, Jigsaw, Group Investigation, Think Pair Share and Numbered Heads Together as cooperative learning models. The STAD model of cooperative learning was developed by Slavin (1983, 1995) in Arends (1997). In this model, students are divided into four or five member teams and the teacher presents academic information to students each week using verbal presentation or text. Team members use work sheets or other study devices to master the academic materials and then help each other learn the materials through tutoring, quizzing one another and discussions. Teams then present reports of their work to the other students. Individually, students take weekly or biweekly quizzes on the academic materials which are scored, and each individual is given a score. A team average score is calculated and an announcement is made of the teams with the highest average score, students with highest improvement scores and students who have perfect scores on the quizzes. STAD was adopted in this study because it is the simplest and straightforward model of the cooperative learning approach (Arends, 1997).

Effects of cooperative learning

Cooperative learning has many positive effects on a range of student outcomes including academic achievement and social skills development (Ferrer, 2004). According to Agashe (2004), cooperative learning was found effective in teaching science in a school in India where it improved individual achievement and development of social skills among learners. LaCarrubba (1993) reported that during cooperative lessons, primary school children were actively involved in reading, listening, discussing or performing tasks and students expressed the desire to continue with the task. She further observed that shy, quiet students began to express opinions and preferences within their cooperative group and began to participate more regularly in the whole class discussions. Research studies in diverse school settings and across a wide range of content areas have revealed that students engaged in cooperative

learning approach tend to have higher academic test scores, higher self-esteem, higher-level reasoning skills, collaborative skills, greater numbers of positive social skills, fewer stereotypes of individuals of other races or ethnic groups, and a greater comprehension of the content and skills they learn (Johnson et al., 2000).

In a study where Junior Secondary Students were taught social studies in Nigeria, those taught through cooperative learning approach performed better than their counterparts who were taught through the traditional teaching approach (Adeyemi, 2008). Aronson (2002) reports that elementary students taught through Jigsaw cooperative learning approach learnt material faster and performed significantly better on examinations than a control group of students learning the same material through regular teaching methods. Effandi and Zanaton (2007) further reports that an experimental group of students who were instructed through cooperative learning approach showed significantly higher scores in a mathematics achievement test and problem solving skills than a control group that was instructed through the traditional lecture method. Over 500 research studies back the conclusion that cooperative learning produces gains across all content areas, all grade levels, and among all types of students including special needs, high achieving, gifted, urban, rural, and all ethnic and racial groups (Ho et al., 2007). Wachanga et al. (2004) reported that secondary school students who were taught chemistry through the cooperative learning approach in Nakuru district, Kenya outperformed those who were taught through the traditional teaching approaches. Similarly Ho et al. (2007) reported that cooperative learning approach increased academic achievement and motivation to learn physics among secondary school students in Hong Kong as compared to those who were taught through the traditional teaching approaches. Armstrong et al. (2007) in a study that compared cooperative learning approach and traditional lecture method in an undergraduate biology course reported that the experimental group that was instructed through cooperative learning approach showed greater improvement in overall test scores than control group that was taught using a traditional lecture approach. He further noted that the experimental group performed significantly better on questions requiring both factual knowledge and comprehension than students in the control group who were instructed through the regular lecture format. Wachanga and Mwangi, (2004) found no significant differences between boys and girls who were exposed to cooperative learning in chemistry. In addition, boys and girls in the experimental groups who were instructed through cooperative learning in chemistry outperformed their counterparts in the control group who were instructed through the traditional teaching approach. However a study by LaCarrubba (1993) using the STAD model of cooperative learning concluded that there was no significant difference in science achievement scores of primary school students taught through the cooperative learning method and those taught through direct reading activity which was considered as a traditional teaching method. Similarly More et al. (1992) compared the effects of STAD cooperative learning model with the traditional teaching approach and reported that no significant differences between the control and experimental groups were observed.

Several studies have reported that cooperative learning approach promote higher academic achievement than the traditional teaching approaches. In addition it promotes the development of social skills such as conflict resolution, problem solving skills, among others that are important in school, work place and life in the community. Literature review has not revealed any study on the effect of cooperative learning approach on biology achievement scores in Kenya. Therefore this study attempts to fill this knowledge gap and contribute to the body of knowledge on cooperative learning approach.

Statement of the problem

The GoK is committed to improve the quality of education and in particular the quality of science education for socio-economic development and technological advancement of the country (GoK, 2007, 2005). However achievement in Biology at the secondary school level nationally has been low and in Machakos district it has been lower than the national average. One factor cited for low achievement is the teaching approaches adopted by a teacher, and while it is acknowledged that learner-centred teaching approaches promote higher academic achievement and a more positive attitude towards a subject as compared to teacher-centred approaches, the teacher-centred approaches are predominantly practised at secondary school level in Sub-Sahara Africa (Kolawole, 2007; UNESCO, 2005).

Cooperative learning approach actively involves learners in the teaching and learning process thereby promoting more learning and higher academic achievement than traditional teacher-centred approaches (Agashe, 2004). It also promotes a more positive attitude towards the subject which is essential for enhancing learning. Studies have confirmed that use of cooperative learning approach improves academic achievement and interest towards the subject. Therefore use of cooperative learning approach is likely to improve secondary school student achievement scores in biology in Kenya. Review of literature has not revealed any studies on the effectiveness of cooperative learning approach in the teaching and learning of biology in Kenya and this study will fill this gap in the body of knowledge on the effectiveness of cooperative learning approach. Therefore, this study aims at finding out the effect of cooperative learning approach on mean achievement scores in biology of secondary students in Machakos District, Kenya.

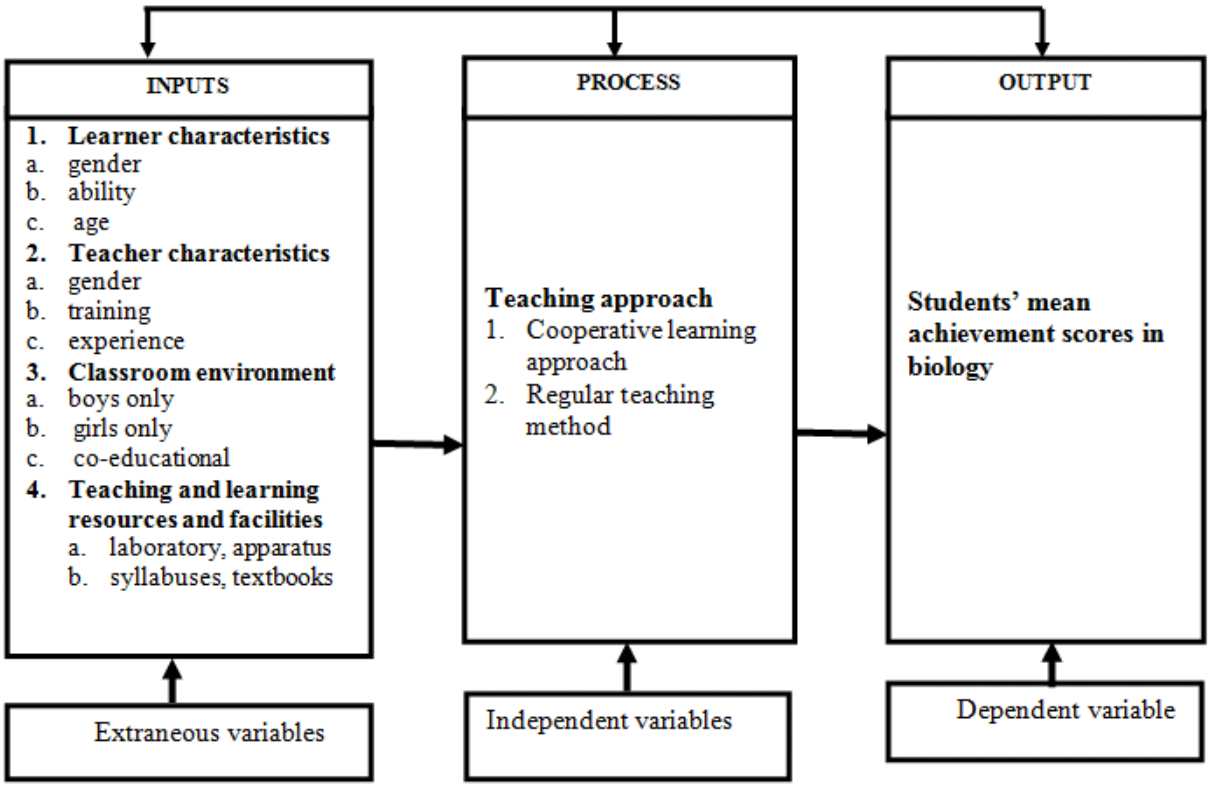

Figure 1. Elements of teaching and learning system. **(**Ayot and Patel, 1992).

Research hypotheses

The study was premised on the null hypotheses that:

(a) **H_1:** there is no statistically significant difference in biology mean achievement scores of secondary school students who are exposed to cooperative learning approach and those who are not so exposed.
(b) **H_2:** there is no statistically significant difference in biology mean achievement scores in different cognitive domain levels for secondary school students who are exposed to cooperative learning approach and those who are not so exposed.
(c) **H_3:** there is no statistically significant difference in biology mean achievement scores between secondary school male and female students who are exposed to cooperative learning approach.

These hypotheses were tested and accepted or rejected at a significant level of $P \leq 0.05$.

Conceptual framework for the study

The conceptual framework in this study adapted the systems theory in education which depicts the t aching and learning process as having inputs that interact to produce outputs (Figure 1).

According to Ayot and Patel (1992), all systems have common characteristics which include: Well defined goals; more than one element which work in harmony; and provides feedback. In education, these conditions are satisfied in that there are inputs which include learners, teachers, and teaching and learning resources among others; the process is the transformation of learners' behaviour through the teaching-learning process; and the output are adults who are well adjusted to fit in the society. In the context of teaching and learning, the learner is the input and through the teaching-learning process, the learner undergoes desirable changes. The performance of the learner is the output which provides feedback about the teaching-learning process. Therefore, through manipulation of the teaching-learning process by adopting cooperative learning approach, it is possible to produce desirable outputs in the form of higher achievement scores In Biology.

The extraneous variables in this study were learner characteristics; teacher characteristics; classroom environment; and teaching and learning resources. To control for the teacher characteristics, only trained teachers of more than two years of teaching experience were used in the four schools. This controlled for training and experience of the teacher. To control for classroom environment, only co-educational schools were used in this study. To control for the teaching and learning

Group 1	O_1	X	O_2
Group 2	O_3	C	O_4
Group 3	----	X	O_5
Group 4	----	C	O_6

Figure 2. Solomon Four Non-Equivalent Control Group Design (Best and Kahn, 2003).

resources and facilities, the four schools selected for the study were visited to ascertain that they had a laboratory which was adequate for teaching and learning of Biology and that the learners at form two had adequate Biology course textbooks. For the learner characteristics, the variable of sex was built into the study as the second independent variable to answer the question of whether there are gender differences in Biology mean achievement scores as a result of cooperative learning approach. The schools that were selected had comparable KCSE performance index to control for initial differences in students' academic abilities. In addition pre-test and KCPE scores were used as covariates to statistically establish equivalence and compensate for any initial differences in students academic ability.

METHODOLOGY

Research design

This study was meant to determine the effect of cooperative learning approach on Biology mean achievement scores of secondary school students. Therefore the study was designed as an experiment where the teaching approach was the independent variable while the mean achievement scores in biology was the dependent variable. Cooperative learning approach was the experimental variable while the regular teaching method was the control condition. According to Robson (2002), an experimental design is employed where participants are assigned to different conditions; there is manipulation of one or more independent variables by the experimenter; there is measurement of the effects of this manipulation on one or more dependent variables; and there is control of all other variables. This study fitted this description of an experimental design in that the effect of cooperative learning approach was compared with the regular teaching method at the end of the five weeks treatment period to determine whether it had a significant effect on secondary school students' mean achievement scores in biology. An experimental design is a strong design for a researcher to test hypotheses to reach valid conclusions between independent and dependent variables (Best and Kahn 2003). According to Wiersma (2000), a true experimental design requires experimental and control groups which are made equivalent through random assignment of subjects into experimental and control groups.

According to Best and Kahn (2003), it is difficult to ensure equivalence of the experimental and control groups in a school by random assignment of students because classrooms are formed as intact groups that cannot be dismantled for the purpose of a study. Therefore this study adapted the Solomon Four Non-Equivalent Control Group Design (Figure 2) as a Quasi-Experiment. This meant that there was no randomization because secondary school students in Kenya are found in intact groups of classes and the school management in the four schools where the study was conducted could not allow randomization of students for the purpose of this study. It was also unethical to randomize students for the purpose of this study. The Solomon Four Non-Equivalent Control Group Design is strong enough to compare the effect of a treatment and can control all major threats to internal validity except those associated with maturation, history, and instrumentation (Cook et al., 1979 in Best and Kahn, 2003). For this study, form two students of relatively the same age were used to control for maturation. In addition, no catastrophic event was observed during the study and therefore history was not a threat to internal validity. The instrument used in this study was assessed by a team of experts for content validity while a reliability coefficient of 0.84, 0.67 and 0.89 was attained at pilot testing, pre-testing and post-testing respectively and this controlled the threat of instrumentation. Solomon Four Non-Equivalent Control Group Design has been used successfully in research studies to determine the effect of teaching approaches on student achievement scores in Kenya (Wambugu and Changeiywo 2008; Wachanga and Mwangi, 2004).

This experimental design adopted symbols as proposed by Wiersma (2000). Groups 1, 2, 3 and 4 were co-educational schools that were randomly assigned to the experimental and control groups. O_1 and O_3 were pre-tests while O_2, O_4, O_5 and O_6 were post-tests. Both the pre-test and post-test was the Biology Achievement Test (BAT) which was constructed by the researcher for the purpose of this study. X represents the treatment variable which in this study was the cooperative learning approach, while C represents the control condition which in this study was the regular teaching method. The dotted line between groups 1, 2, 3 and 4 indicates that the groups that were used in this study existed as intact groups and therefore there was no randomization of students when establishing the treatment and control groups. Groups 1 and 3 were the experimental groups that received the treatment (X) while group 2 and 4 were the control groups that were kept under the control condition (C). Groups 1 and 2 were pre-tested (O_1 and O_3) while groups 3 and 4 were not pre-tested. All the four groups were then post tested (O_2, O_4, O_5 and O_6) at the end of the five weeks treatment period.

The intervening variables that needed to be controlled in this study include: The teacher characteristics (professional qualifications, teaching experience and readiness to practice cooperative learning approach); students' characteristics (age, gender and ability); classroom environment (boys only, girls only and co-educational); and teaching and learning resources and facilities (laboratory, apparatus, syllabuses and textbooks). To control for teachers' training and experience as sources of internal

invalidity, only trained teachers with more than two years of teaching experience were chosen. To control for the teachers readiness to implement cooperative learning approach, the teachers in experimental schools were trained on how to use cooperative learning approach. Form 2 students of approximately the same age were used to avoid the threat of maturity to internal validity. The sex of the student was built into the study to determine whether there are gender differences in mean achievement scores in biology as a result of exposure to cooperative learning approach. To control classroom environment only co-educational schools were used in this study. The researcher obtained information from the district education office about the facilities in the co-educational schools in Machakos district prior to their selection for the study to ascertain that the selected schools were of comparable characteristics in terms of teaching and learning facilities. The teachers in the experimental groups were trained by the researcher for one week on how to implement STAD model of cooperative learning approach in their classrooms during the treatment period. The researcher prepared a Cooperative Learning Implementation Manual (CLIM) which described how to implement the STAD model of cooperative learning approach. This manual was then used to guide teachers in the experimental schools (Group 1 and 3) on how to implement STAD model of cooperative learning approach in their classrooms during the treatment period. The teachers then used the manual as a guide during the implementation period.

The students in the experimental schools were divided into teams of five members with each member having a specific role in the group: Leader, monitor, recorder, resource manager and reporter. The group leader facilitated group discussions, by ensuring that the team remained focused on the set academic goals and worked to meet them; the monitor ensured that everyone got equal opportunity to participate and also monitored the time spent on each task; the resource manager gathered and organized materials for the team activities; the recorder kept written records of team reports and answers; and the reporter shared team reports and answers during whole class discussions. The team composition was heterogeneous in terms of gender and ability. The KCPE score was used as a measure of students' ability during team formation. Ten teams were formed in each of the two experimental groups. During the five weeks study period, a total of 20 lessons of 40 min each were taught in both control and treatment groups. In the treatment groups, each lesson began as a whole class instruction for 10 min when the teacher made an exposition focussing on what the students were expected to do during the lesson. The students then went into their cooperative teams for 15 min where they were provided with worksheets that directed them on what to do. In these cooperative teams students read selected texts from the form two approved biology course books or carried out practical activities. They finally discussed and answered questions on the work sheets. The students in a team had to discuss the questions in the worksheet and come to a team consensus about the answer to put down. Upon completion of the worksheets, the last 15 min of the lesson were spent by the entire class discussing the correct answers to the questions in the worksheets. The teacher read a question aloud and randomly picked a team and the reporter in that team responded to the question. Correct response was applauded by the whole class and earned one team point. If the response was not satisfactory, the question was presented to another team which then earned an extra point for correct response. The questions were proportional to the number of teams. At the end of a lesson, the team with the highest points was recognised and applauded. At the end of a sub-topic, the students took a quiz which the teacher scored and calculated a team average score. The teacher announced the teams with the highest average score which was then applauded by the whole class. In addition students who had perfect scores were recognised through applause. In the control groups, the regular teaching method which was predominantly the lecture method was used. In this method, the teacher presented information on the topic as an exposition to the whole class while the students listened passively as they took notes individually. There were very minimal and incidental interactions between the students. In addition, the students in control groups were rarely asked questions by the teacher and likewise they rarely asked questions.

Target population

The target population in this study were form two students in Machakos district, Kenya while the accessible population were form two students in four co-educational secondary schools selected in Machakos district. Form two students were considered appropriate for this study because they had not yet selected the science subjects that they would be entered for the KCSE examination. Secondly form two students had been exposed to the secondary school curriculum for one year and therefore were considered to be adjusted to secondary school curriculum unlike the form one students who were considered to be adjusting to a new curriculum at secondary school. Form two students are in their second year of secondary education cycle in Kenya and students in the sample had a mean age of 16.94 years. A sample of 183 form two students was obtained and this was appropriate for statistical inferences.

Sample and sampling procedures

This study adopted purposive sampling so as to select the four co-educational secondary schools with comparable characteristics from Machakos district. Purposive sampling is appropriate where the researcher has previous knowledge of the population and has a specific purpose for the study and therefore use personal judgment to select a sample (Fraenkel and Wallen, 2002). The researcher therefore used his knowledge of the target population to judge whether or not students in a particular school were a suitable sample. A list of co-educational secondary schools in Machakos district was obtained from the District Education Office from which a sample of four co-educational schools was selected. The factors that were considered for the selection included: school mean performance index at 2007 KCSE examination; student enrolment in form two; adequacy of teaching and learning resources; and geographical location of the school. The information on KCSE performance index, student enrolment and geographical location of the schools was obtained from the District Education Office. The researcher visited the selected schools and ascertained their suitability for the study which included: adequate enrolment of students at form two; availability of trained and experienced biology teachers; and adequate teaching and learning resources and facilities for teaching Biology. This exercise ensured that the four co-educational schools that were selected had comparable characteristics for this study.

The four co-educational secondary schools were then randomly assigned to treatment and control groups which controlled for interaction between selection and maturation (Best and Kahn, 2003). A four sided dice was used with each side labelled as follows: 1 (Experimental Group); 2 (Control Group); 3 (Experimental Group); and 4 (Control Group). The four schools were listed alphabetically and the outcome of the first, second, third and fourth toss was assigned to the first, second, third and fourth school on the list, respectively. All the four co-educational schools had three form two classes and one class in each school was randomly selected for the study through the rotary method. However, biology teachers in the experimental schools were encouraged to expose all the students in form two to cooperative learning approach for ethical reasons but only data from the sampled class was used in this study for statistical analysis.

Table 1. BAT items by cognitive domain levels.

Cognitive level	Test items	Number of items	Score
Knowledge	1 to 6	6	9
Comprehension	7 to 15	9	12
Application	16 to 20	5	16
Total	20	20	37

Data collection instrument

The BAT was the instrument used in this study to measure students' mean achievement score in biology. It consisted of twenty short answer structured items with a maximum score of 37 based on "gaseous exchange in plants and animals", a topic that is taught at form two as prescribed in the Secondary Education Syllabus Volume Two (KIE, 2002). The short answer item format was modelled on the KNEC Biology Paper One which was considered appropriate as it is a familiar format at secondary school level in Kenya (KNEC, 2005). The twenty test items were set and categorised into three cognitive domain levels adapted from the Blooms Taxonomy of Educational Objectives in the Cognitive Domain (Bloom, 1956). The BAT test items were based on the first three cognitive levels of knowledge, comprehension and application. This classification of the BAT test items into three cognitive domain levels enabled the researcher to determine the effect of cooperative learning approach on student achievement in different cognitive abilities (Table 1).

Items based on knowledge cognitive level required students to memorize and recall information and there were six items in this category with a total score of 9. Items based on comprehension cognitive level required students to demonstrate understanding of concepts and there were nine items in this category with a total score of 12. The items based on application cognitive level required students to use prior information to solve unfamiliar problems and in this category were five items with a total score of 16. Therefore the total number of items in BAT was 20 with a total score of 37. A table of specification was used to sample both the content in Gaseous Exchange in Plants and Animals and the three cognitive levels during the construction of the test items.

The BAT instrument was evaluated by researchers in biology and in-service teacher trainers at CEMASTEA to ascertain its content validity. These experts are trained biology teachers with a teaching experience of over 15 years. In addition the experts had experience as examiners in Biology and in-service training of Biology teachers in Kenya. They ascertained that the BAT test items were based on the content and specific objectives of "gaseous exchange in plants and animals" as prescribed in the Secondary School Biology Syllabus (KIE, 2002). The experts also ascertained that the BAT items were accurately categorized into knowledge, comprehension, and application cognitive domain levels. To ascertain reliability of the BAT instrument, the test was pilot-tested using a co-educational school in a District that was not part of the study but had comparable characteristics as the sample schools. The reliability coefficient of the BAT was calculated using the Cronbach's alpha (Hopkins, 1998). The Cronbach's alpha generates a coefficient of internal consistency ranging from 0 to 1.0 and is suitable when test items have more than dichotomous, right-wrong scores such as short answer questions. The following formula was used:

$$\alpha \text{ (Alpha)} = [n/(n-1)] \times [(S^2_t - \Sigma S^2)/ S^2_t]$$

Where;
α = estimated reliability of the test.
n = number of test items.
S^2_t = variance of the whole test (standard deviation squared).
ΣS^2 = sum of the variance for all n items.

Therefore the coefficient alpha was found appropriate for BAT which consisted of short answer items. According to Fraenkel and Wallen (2000), an alpha coefficient of 0.7 and above is considered suitable to make accurate group inferences. Therefore the acceptable level of reliability for BAT in this study was 0.7 and above. At pilot testing a Cronbach Alpha reliability coefficient of 0.84 (N=59) was attained. This was above the threshold level of 0.7 and therefore the BAT instrument was considered reliable for use in the study. During pre-testing a reliability coefficient of 0.67 (N=100) was attained while at post-testing a reliability coefficient was 0.89 (N=183) was attained. Therefore the BAT was a reliable instrument and scores obtained using this instrument could be used to make accurate group inferences.

Data collection procedures

Research authorization and permit to conduct this study was granted by the National Council of Science and Technology (NCST), a government agency in the Ministry of Higher Education, Science and Technology (MHEST) in Kenya. Before commencement of the study, the researcher visited the District Education Office in Machakos District and the four study schools to determine the workability of schedule of activities. This involved determining extent of syllabus coverage in biology at form two, allocation of Biology lessons in the master time table and the schools' calendar of events for the second school term of 2009. At the commencement of the study a BAT pre-test was administered to students in Groups 1 and 2. Group 1 was an experimental group while Group 2 was a control group. At the end of the experimental treatment which lasted five weeks, a BAT post-test was administered to students in all four groups. Both the pre-test and post-test were administered under similar conditions in both experimental and control schools and were supervised by the researcher and the regular teacher. The pre-tests and post-tests were then scored by the researcher using a marking scheme prepared and validated by the team of experts in biology. The team of experts then validated the scoring of the BAT pre-test and post-test.

The researcher ascertained that the teachers in the experimental schools were not familiar with cooperative learning approach and had not used this approach before in their teaching. The teachers in the experimental schools then practised on how to implement cooperative learning in their classes for a week under the guidance of the researcher in a topic that was different from the topic that was used in this study. During the experiment, the researcher visited the classrooms in the experimental schools and ascertained that the STAD model of cooperative learning was administered as prescribed. The teachers in the two control schools (Groups 2 and 4) were neither provided with the CLIM nor were they trained on how to implement STAD model of cooperative learning. Therefore they used the regular teaching methods (RTM) to teach "gaseous exchange in plants and animals". The researcher also visited the classrooms in the control schools and ascertained that cooperative learning approach was not used. A total of 20 lessons were taught in both the experimental and control groups during this study.

Table 2. Independent samples t-test of BAT pre-test scores based on groups.

Variable	Group	N	Mean	S.D	S.E	t-value	p-value
BAT pre-test	1	46	3.74	2.31	0.34	-2.963	0.004
	2	54	5.33	2.96	0.40		

(t=-2.963, d.f=98, p<0.05), Cohen d = 0.60.

Table 3. Independent samples t-test of BAT pre-test scores based on gender.

Variable	Gender	N	Mean	S.D	S.E	t-value	p-value
BAT pre-test	Male	53	5.38	2.62	0.36	3.089	0.003
	Female	47	3.72	2.73	0.40		

(t=3.089, d.f=98, p<0.05), Cohen d = 0.31.

Data analysis procedures

The data obtained from this study included the BAT achievement scores and background information on students. This data was analysed using the Statistical Package for Social Sciences (SPSS) version 17. The BAT pre-test and post-test scores and student background information were keyed into SPSS version 17 for further analysis. The statistical tests that were done included: ANOVA, ANCOVA, regression, independent samples t-test and paired samples t-test. In all the statistical tests, the study hypotheses were rejected or accepted at the significant level of P≤0.05. ANOVA was used to estimate BAT means achievement post-test score differences in the four groups and in the three cognitive levels. The F-statistic was used to determine whether any observed differences in means were significant. Post hoc comparison was done with Scheffe's test to identify the location of statistically significant mean differences. ANCOVA was used to detect initial group differences using the students' KCPE score as covariate so as to adjust for any initial differences in the post-test scores and thereby establish group equivalence statistically**.** The simple ordinary least squares regression analysis was used to evaluate the extent to which the KCPE score predicted the BAT post test score so as to further justify the appropriateness of using the KCPE score as a covariate when carrying out ANCOVA on BAT post-test mean achievement scores. The independent samples t-test was used to determine the significance of any observed differences between two means because of its superior power in detecting differences between two means. This was used to estimate mean differences between groups 1 and 2, groups 1 and 3, and gender in experimental groups. The paired samples t-test was used to determine the mean gains between pre-test scores and post-test score in groups 1 and 2.

RESULTS

Initial group and gender differences

Independent samples t-test was carried out on the BAT pre-test mean achievement scores for Group 1 (experimental) and Group 2 (control) and for male and female students to determine whether the groups were equivalent before the start of the treatment (Tables 2 and 3). Statistically significant differences were observed between Groups 1 and 2 (t=-2.963, d.f=98, p<0.05) with strong effect size (d=0.60) and between male and female students (t=3.089, d.f=98, p<0.05) with a modest effect size (d=0.31). Therefore ANCOVA was used to correct for these differences to establish statistical equivalence for comparison of BAT post-test mean achievement scores.

Effect of CLA on biology means achievement scores

The first null hypothesis (Ho_1) in this study tested the effect of cooperative learning approach on students' biology mean achievement scores. One-way ANOVA was carried on students' BAT post-test scores to estimate the effect of cooperative learning approach on student's biology mean achievement score (Figure 3) and (Table 4). The differences in mean achievement scores among the four groups were statistically significant at [F=70.29, d.f= (3, 179), p<0.05]. This finding shows that there was a high and significant overall treatment effect.

In order to find out where the significant differences were located post hoc comparison using Scheffe's test of significance difference between any two means in the four groups was carried out (Table 5). The BAT post-test mean achievement scores for Groups 1 and 2, Groups 1 and 4, Groups 2 and 3, and Groups 3 and 4 were significantly different at p<0.05. However, there was no statistically significant difference in the BAT post-test mean achievement scores between Groups 1 and 3 and Groups 2 and 4 at P<0.05.

Since this study involved Solomon Four Non-Equivalent Control Group Design and initial group and gender differences were detected at pre-testing, there was need to confirm these findings by performing ANCOVA of the BAT post-test mean achievement scores with the students' KCPE scores as a covariate. The KCPE score

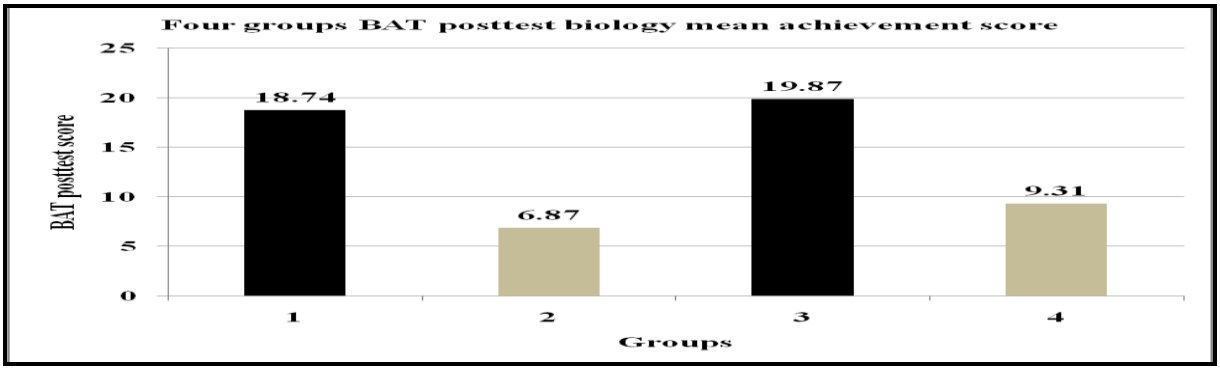

Figure 3. Four groups BAT post-test biology mean achievement scores.

Table 4: ANOVA on BAT post-test scores .

Score	Sum of squares	d.f	Mean square	F-value	p-value
Between groups	6172.493	3	2057.498	70.287	0.000
Within groups	5239.835	179	29.273		
Total	11412.328	182			

(F=70.287, d.f= (3,179), p<0.05).

was considered an appropriate covariate because regression analysis indicated that the KCPE score significantly predicted the BAT post-test mean achievement score (t=6.047, p<0.05, R^2=0.163) with a moderate model fit (Table 6). Therefore it was assumed that the student' KCPE score was an adequate measure of their academic ability which can explain the initial group and gender differences observed at pre-test.

Therefore ANCOVA with Sidak adjustment was carried on the BAT post-test mean achievement scores with the KCPE score as a covariate and confirmed that the differences between the four groups means were significant at [F=79.912, d.f= (3,178), p<0.05] and a strong effect size (Eta=0.57) was observed (Table 7). To locate the significant differences between the Groups, the Scheffe's post hoc pair-wise comparisons test based on the ANCOVA was carried out which further confirmed significant differences between Groups 1 and 2, Groups 1 and 4, Groups 2 and 3, and Groups 3 and 4 while differences between Groups 1 and 3, and Groups 2 and 4 were not statistically significant (Table 8). The mean achievement scores of Groups 1 and 3 were almost similar but higher than for Groups 2 and 4 which implies that the pre-test did not interact significantly with the treatment and therefore did not affect students' learning (Table 9).

The paired samples t-test between BAT pre-test and post-test mean scores indicated that Group 1 (t=16.893, d.f=45, p<0.05) and Group 2 (t=-3.440, d.f=53, p<0.05) gained significantly from the teaching (Table 10). However Table 11 shows that the mean gain between students' BAT pre-test scores and post-test scores was higher for the experimental than the control group. The use of cooperative learning approach resulted in higher students' academic achievement in biology as compared to the regular teaching methods since Groups 1 and 3 which were the Experimental Groups in this study obtained significantly higher BAT mean achievement scores compared to Groups 2 and 4 which were the Control Groups. Therefore the first null hypothesis (Ho_1) was rejected.

Effect of CLA on Biology mean achievement scores in different cognitive abilities

The second null hypothesis (Ho_2) was meant to test the effect of cooperative learning approach on student' biology achievement scores at three cognitive domain levels: knowledge, comprehension and application. This null hypothesis was evaluated by carrying out ANCOVA on the BAT post-test mean achievement scores in the three cognitive domain levels of knowledge, comprehension and application with KCPE score as covariate (Tables 12, 13 and 14). Statistically significant mean differences were observed at all three cognitive domain levels: knowledge ((F=53.97, d.f= (3,178), p<0.05)); comprehension ((F=35.81, d.f= (3,178), p<0.05)) and application ((F=58.94, d.f= (3,178), p<0.05)) with strong effect sizes of 0.48, 0.38 and 0.50, respectively. The BAT items in the three cognitive domain levels had different total scores: Knowledge (9); comprehension

Table 5. Scheffe's post hoc comparison test of BAT post-test score means.

(I) Group	(J) Group	Mean difference (I-J)	S.E	p-value
Group 1	Group 2	11.869(*)	1.09	0.000
	Group 3	-1.133	1.12	0.796
	Group 4	9.434(*)	1.20	0.000
Group 2	Group 1	-11.869(*)	1.09	0.000
	Group 3	-13.002(*)	1.08	0.000
	Group 4	-2.435	1.16	0.227
Group 3	Group 1	1.133	1.12	0.796
	Group 2	13.002(*)	1.08	0.000
	Group 4	10.567(*)	1.20	0.000
Group 4	Group 1	-9.434(*)	1.20	0.000
	Group 2	2.435	1.16	0.227
	Group 3	-10.567(*)	1.20	0.000

* The mean difference is significant at p<0.05 level.

Table 6. Regression of BAT post-test scores with KCPE scores.

Model 1	Un-standardized coefficients		Standardized coefficients	t-value	p-value
	B	**S.E**	**Beta**		
(Constant)	-9.745	3.909		2.493	0.014
KCPE Marks	0.088	0.015	0.410	6.047	0.000

(Adjusted R Square = 0.163, t=6.047, p<0.05).

Table 7. ANCOVA on four groups BAT post-test score with KCPE as covariate.

Source	Sum of squares	d.f	Mean Square	F-value	p-value	Effect size
KCPE	1194.374	1	1194.374	52.552	0.000	0.228
Group	5448.579	3	1816.193	79.912	0.000	0.574
Error	4045.461	178	22.727			

(F=79.912, d.f= (3, 178), p<0.05).

(12); and application (16) and therefore the pre-test and post-test mean scores for each cognitive level were standardized for comparison (Table 15). Group 1 had higher standardized mean gain than Group 2 at all three cognitive domain levels. For Group 1, the standardized mean gain was higher at comprehension and least at application level. For Group 2 the standardized mean gains were negative with knowledge having the lowest gain and application the highest mean gain. This result indicates that there was a high treatment effect at all three cognitive levels. Since Groups 1 and 3 (Experimental Groups) were taught through the cooperative learning approach while Groups 2 and 4 (Control Groups) were taught through the regular teaching method, and the cooperative learning approach resulted in higher achievement at knowledge, comprehension and application cognitive domain levels as compared to the regular teaching method, the second null hypothesis (Ho_2) was rejected.

Effect of CLA on biology mean achievement score based on gender

The third null hypothesis (Ho_3) tested whether there were statistically significant gender differences in student mean achievement scores in biology as a result of exposure to

Table 8. ANCOVA pair-wise comparisons of BAT post-test means with KCPE as covariate.

(I) Group	(J) Group	Mean difference (I-J)	p-value
Group 1	Group 2	10.663(*)	.000
	Group 3	-0.034	1.000
	Group 4	11.311(*)	0.000
Group 2	Group 1	-10.663(*)	0.000
	Group 3	-10.697(*)	0.000
	Group 4	0.648	0.993
Group 3	Group 1	0.034	1.000
	Group 2	10.697(*)	0.000
	Group 4	11.345(*)	0.000
Group 4	Group 1	-11.311(*)	0.000
	Group 2	-0.648	0.993
	Group 3	-11.345(*)	0.000

* The mean difference is significant at the .05 level, Adjustment for multiple comparisons: Scheffe.

Table 9. Adjusted BAT post-test mean scores for ANCOVA with KCPE score as covariate .

Group	1	2	3	4	Total
N	46	54	47	36	183
Mean	19.04	8.37	19.07	7.72	13.55

Covariates appearing in the model are evaluated at the following values: KCPE score = 265.84.

Table 10. Paired samples t-test of BAT pre-test and post-test for groups 1 and 2.

Group	Paired variables	Paired mean differences	S. D	S.E	t-value	d.f	p-value
1 (N=46)	pre-test - post-test	-15.00	6.02	0.89	-16.893	45	0.000
2 (N=54)	pre-test - post-test	-1.54	3.28	0.45	-3.440	53	0.001

Table 11. Comparison of students' means gain in BAT.

Variable	Group 1 (N=46)	Group 2 (N=54)	Overall (N=100)
Pre-test	3.74	5.33	4.54
Post-test	18.74	6.87	12.81
Mean gain	15.00	1.54	8.27

cooperative learning approach. Independent samples t-test was carried out on the BAT post-test scores for male and female students who were exposed to cooperative learning approach and no significant differences (t=1.617, d.f=91, p>0.05) were observed between the mean achievement scores of the 52 male and 41 female students (Table 16). This implies that both male and female students can perform equally well when exposed to cooperative learning approach. Therefore the third null hypothesis (Ho_3) was not rejected.

DISCUSSION

Effect of CLA on biology achievement

The findings from this study shows that students who were taught through cooperative learning approach achieved statistically significantly higher achievement scores in BAT compared to those who were taught through the regular teaching method. This implies that cooperative learning approach was more effective in enhancing student'

Table 12. ANCOVA of the BAT post-test score in knowledge level items .

Source	Sum of squares	d.f	Mean square	F-value	p-value	Effect size (Eta)
KCPE	114.679	1	114.679	40.301	0.000	0.19
Group	460.710	3	153.570	53.968	0.000	0.48
Error	506.516	178	2.846			

[(F=53.97, d.f=3,178, p<0.05)].

Table 13. ANCOVA of the BAT post-test score in comprehension level items.

Source	Sum of squares	d.f	Mean square	F-value	p-value	Effect size (Eta)
KCPE	149.829	1	149.829	37.840	0.000	0.18
Group	425.332	3	141.777	35.807	0.000	0.38
Error	704.798	178	3.960			

[(F=35.81, d.f= (3,178), p<0.05)].

Table 14. ANCOVA of the BAT post-test score in application level items .

Source	Sum of squares	d.f	Mean square	F-value	p-value	Effect size (Eta)
KCPE	134.802	1	134.802	22.972	0.000	0.12
Group	1037.559	3	345.853	58.939	0.000	0.50
Error	1044.509	178	5.868			

[(F=58.94, d.f= (3,178), p<0.05)].

achievement scores in biology than the regular teaching methods. A study conducted by Ho et al. (2007) showed that secondary school students with minimal prior knowledge of specific physics content had higher achievement when taught through the cooperative learning approach than those taught through the regular teaching method. Armstrong et al. (2007) in a study that compared cooperative learning approach and traditional lecture method in an undergraduate biology course reported that the experimental group that was instructed through cooperative learning approach showed greater improvement in overall test scores than control group that was taught using a traditional lecture approach. Similarly Wachanga et al. (2004) found that the cooperative learning approach produced significantly higher achievement scores in secondary school chemistry students as compared to the regular teaching method. The findings from the current study showed a statistically significant difference ($p<0.05$) in biology achievement scores with students who had no prior knowledge of the biology content when taught through the cooperative learning approach as compared to the regular teaching approach and therefore concurs with the findings of previous research.

Traditional teaching approaches create classroom settings for competition where learning is viewed as a commodity to be competed for with students regarding their colleagues as opponents (Ali et al., 2007). On the other hand, cooperative learning approach improves academic achievement because it enable the learner to receive positive feedback from the process of thinking, problem solving and group discussion which results in better comprehension and deeper understanding of the subject content matter. The active involvement of students through cooperative team activities enhances the students understanding and ability to integrate and synthesize academic material. According to Johnson et al (1994), cooperative learning is the structuring of small groups so that students work together to maximize their own and each other's learning by helping one another and sharing ideas. The use of small groups with students of different levels of ability maximizes learning activities to improve their understanding of a subject (Agashe, 2004; Liang and Gabel, 2005). The participation of every student in the team, cooperation among team members and the rewards for individual and collective efforts is important for understanding the subject matter. As the students work together in the teams, listening, engagement and empathy which are essential for an academic activity are encouraged (Aronson, 2002).

Table 15. BAT standardized means of groups 1 and 2 in three cognitive domain levels.

Variable	Group 1 (N=46)			Group 2 (N=54)		
	Knowledge	Comprehension	Application	Knowledge	Comprehension	Application
Pre-test	-0.351	-0.339	-0.001	0.299	0.289	0.001
Post-test	0.311	0.752	0.606	-0.858	-0.680	-0.776
Mean gain	0.662	0.786	0.607	-1.157	-0.969	-0.777

Table 16. Independent samples t-test of BAT post-test scores of male and female students exposed to CLA.

Variable	Gender	N	Mean	S.D	S.E	t-value	d.f	p-value
BAT post-test	Male	52	20.29	6.51	0.90	1.617	91	0.109
	Female	41	18.07	6.63	1.03			

(t=1.617, d.f=91, p>0.05).

Group members work together as a team to accomplish a common goal and no student can achieve his or her individual goal of getting a good grade unless everyone works together as a team. This positive interdependence enables students to see that their success is dependent on the contributions, inclusion, and success of the other students in the team. Creating positive interdependence requires a teacher to craft tasks that call for the insights and efforts of more than one student and linking the grades given on an assignment not just to an individual performance on the test but to the performance of the other group members.

In cooperative learning situations, students interact, assist one another with learning tasks, and promote one another's success. The small group setting allows students to work directly with one another, to share opinions and ideas, to come to common understandings, and to work as a team to ensure each member's success and acceptance. Students must have time and opportunity to exchange ideas orally and discuss the concepts at hand. This occurs as structured time for discussion during class, with the discussion scaffolded by a series of questions posed by the teacher. To ensure student discussion, the groups are required to report to the whole the class. In addition, promotive interaction in the teams can be achieved through assigning each student in the team a specific role such as group leader, monitor, recorder, resource manager and reporter. This provides every member of the group an entry point for participation and begins to generate individual responsibility within the group. The aspiration of cooperative learning is to enable all students to benefit from the insights and skills of their colleagues and thus each improve their own learning. The STAD model of cooperative learning approach that was implemented in this study exhibited these characteristics and this explains the higher academic achievement in biology that was observed.

Effect of CLA on biology achievement in different cognitive abilities

This study found that biology students who were exposed to cooperative learning approach had significantly higher mean achievement scores in three cognitive domain levels of knowledge, comprehension and application as compared to those who were taught through the regular teaching method. Higher gain was observed in the comprehension cognitive level. Armstrong et al. (2007) found that undergraduate biology students that were instructed through the cooperative learning approach performed significantly better on questions requiring both factual knowledge and comprehension than students in the control group who were instructed through the regular lecture method. Zafer and Mustafa (2008) found that when university students were taught magnetism through cooperative learning approach it was more effective in remembering learnt knowledge than the conventional teaching method. Similarly, Abdullah and Sharriff (2008) reported that secondary school students who were taught gas laws through cooperative learning approach outperformed those taught through the regular teaching method in conceptual understanding. The findings from the current study are consistent with previous studies. In cooperative teams members are held accountable to provide explanation to others in the team and this presents an opportunity to re-examine their understanding. Interaction of students through discussions in cooperative teams enables them to evaluate different points of view and make decisions on problems which provide them with a better understanding. When students give explanations they need to digest, connect and combine what they already know with the newly developed concept and this enables them to discover further application of newly developed concept (Abdullah and Sharriff, 2008).

Effect of CLA on Biology achievement based on gender

The study found no significant differences in biology achievement scores between male and female students who were instructed through the cooperative learning approach but both performed better than those students who were instructed through the regular teaching methods. Kolawole (2008) reported significant differences in academic achievement between secondary school boys and girls who were taught mathematics through cooperative learning approach. However the sample of 400 students in that study was disproportionately distributed across gender (boys=280, girls=160) and it was therefore important to report the effect sizes to test the strength of the significant differences observed. In addition there could have been initial differences between boy and girl at the beginning of the treatment which were not reported. Wachanga and Mwangi (2004) found no significant differences between boys and girls who were exposed to cooperative learning in chemistry and boys and girls in the experimental groups who were instructed through cooperative learning in chemistry outperformed their counterparts in the control group who were instructed through the traditional teaching approach. Adeyemi (2008) reported no significant differences in the academic achievement of boys and girls of equivalent abilities when they were taught social studies through cooperative learning approach. Similarly Cirila (2003) did not find significant gender differences in mathematics achievement when students were taught through cooperative learning approach.

The findings in the current study are consistent with previous findings and this can partly be attributed on how cooperative teams are structured to encourage participation and interaction. The number of members in a team is important because with increasing number of members, there is a greater possibility that some members will not participate. In the current study, the numbers of members in a team was restricted to a maximum of five. In addition each member had a specific role to play in the group irrespective of their gender and both male and female students were assigned roles without regard to their gender. This enhanced participation and interaction of all team members and all had maximum benefits from the group activities which explain the lack of gender differences in achievement.

Conclusions

This study found that the cooperative learning approach promote higher academic achievement of secondary school students in biology as compared to the regular teaching methods. The approach also enhanced higher academic achievement of secondary school students in biology at knowledge, comprehension and application levels of the cognitive domain as compared to the regular teaching method. Therefore cooperative learning approach enhances conceptual understanding more than the regular teaching method. While using this method there were no significant differences in academic achievement in biology due to the gender of secondary school students and therefore the approach is appropriate for both girls and boys. Therefore the null hypotheses are rephrased to form the alternative study hypotheses as follows:

Ha_1: There is a statistically significant difference in mean achievement scores in biology between secondary school students who are taught through cooperative learning approach and those who are taught through the regular teaching method.
Ha_2: there is a statistically significant difference in mean achievement scores in biology at knowledge, comprehension and application cognitive levels between secondary school students who are taught through the cooperative learning approach and those who are taught through the regular teaching method.
Ha_3: there is no statistically significant difference in mean achievement scores in biology between secondary school male and female students who are exposed to cooperative learning approach.

RECOMMENDATIONS

Based on the research findings and discussions of the study, the following recommendations are made:

1. The findings from this study should find a place in the body of knowledge on cooperative learning approach. The education scholars and particularly specialists in instructional approaches who advocates for active learning strategies, should find an additional voice and companion from this findings. This study is an additional input towards active pedagogy.
2. The findings from this study have proved the effectiveness of cooperative learning approach in enhancing higher academic achievement in biology. Therefore, biology and science teachers in general are encouraged to use cooperative learning approach as a way of improving their students' achievement in the subject. On the other hand it is recommended that in-service and pre-service teacher education training programmes in Kenya and Africa should incorporate cooperative learning approach. This will ensure that science teachers are well grounded on effective teaching and learning approaches for higher academic achievement in these subjects which are the cornerstone for socio-economic development of the society.
3. The findings from this study have demonstrated the effectiveness of cooperative learning approach in enhancing higher academic achievement in biology. For

the benefit of both science teachers and students and considering that cooperative learning approach has many other benefits beyond the academic achievement, it should be promoted as the teaching and learning approach of choice. However, for wider application of this approach, some policy guidelines should be formulated to guide the implementation process. In particular the teachers would require training and reference materials on how to implement cooperative learning approach. Therefore policy makers in education should formulate policy guidelines on modalities of training teachers through in-service and pre-service teacher training programmes on cooperative learning approach. Such policy guidelines geared towards implementation of cooperative learning approach should also inform on development of curriculum support materials

4. Although cooperative learning approach has been widely studied in the developed countries, there are very few studies in Kenya and Africa on the effectiveness of this approach. In addition, the current study focused on the effectiveness of cooperative learning approach on promoting academic achievement in biology. There is need therefore to conduct more studies in other subjects and further confirm the effectiveness of this approach in the Kenyan context. In addition more studies should be conducted at different education levels such as the primary school level, secondary school level and university level to gather more evidence on the effectiveness of the approach. Besides, studies on cooperative learning approach should be extended to other countries in Sub-Sahara Africa where as noted earlier; teacher-centred teaching approaches are pre-dominant. Further research is also recommended to determine the effectiveness of cooperative learning approach in other dimensions such as social development which are equally important for all rounded individual development and social cohesion particularly in Africa where ethnic tensions are prevalent.

ACKNOWLEDGEMENTS

We wish to acknowledge Dr. Githui and Dr. Dimba of the Catholic University of Eastern Africa, for their valuable advice during this study. We also acknowledge professional colleagues at CEMASTEA who spared their time to validity the study instrument and scoring of BAT. There are many others that we may not mention by name and to you all thank you.

REFERENCES

Abdullah S, Sharriff A (2008). The Effect of Inquiry-Based Computer Simulation with Cooperative Learning on Scientific Thinking and Conceptual Understanding of Gas Laws. Eurasia J. Math. Sci. Technol. Educ., 4(4): 387-398. http://www.ejmste.com/v4n4/EURASIA_v4n4_Abdullah.pdf.

Adeyemi BA (2008). Effects of Cooperative Learning and Problem Solving Strategies on Junior Secondary School Students' Achievement in Social Studies. Elect. J. Res. Educ. Psychol., 16(3): 691-708. ISSN 1696-2095. From http://www.investigacion psicopedagogica.org/revista/articulos/16/english/Art_16_181.pdf.

Agashe L (2004). Sustainable Development and Cooperative Learning in the Formal Education System in India. Progress of Education. Pune: Pune Vidyarthi Griha Prakashan.

Ali FA, Sayed HS, Manijeh A, Hassan AM (2007). A Comparison of Cooperative Learning Model on Academic Achievement. J. Appl. Sci., 7(1): 137-140. http://scialert.net/pdfs/jas/2007/137-140.pdf

American Association for the Advancement of Science. (1989). Science for All Americans: Project 2061. Oxford University Press, New York.

Arends RI (1997). Classroom Instruction and Management. Boston, M.A. McGraw Hill.

Armstrong N, Chang SM, Brickman M (2007). Cooperative Learning in Industrial-Sized Biology Classes. Life Sci. Educ., 6: 163-171.

Aronson E (2002). Building Empathy, Compassion and Achievement in the Jigsaw Classroom in Improving Academic Achievement; Impact of Psychological Factors. New York. Academic Press.

Ayot, HO, Patel MM (1992). Instructional methods. Nairobi. Educational Research and Publications Ltd.

Best JW, Kahn JV (2003). Research in Education. Ninth Edition., Prentice-Hall of India Private Limited, New Delhi.

Bloom BS (1956). Taxonomy of Educational Objectives: Cognitive Domain. David McKay, New York.

Brown NR, Oke FE, Brown DP (1982).Curriculum and Instruction; An Introduction to Methods of Teaching. Macmillan Publishers Limited, Kuala Lumpur.

Cirila P (2003). Gender, Abilities, Cognitive Styles and Students' Achievement in Cooperative Learning. Horizons Psychol., 12(4): 9-22.http://psy.ff.uni-lj.si/iGuests/Obzorja/Vsebina1/Vol12-4/peklaj.pdf

Cook TD, Campbell DT (1979). Quasi-Experimentation: Design and Analysis for Field Settings. Houghton Mifflin, Boston.

Effandi, Z., Zanaton, I (2007). Promoting Cooperative Learning in Science and Mathematics Education: A Malaysian Perspective. Eurasia J. Math. Sci. Technol. Educ., 3(1): 35-39.

Ferrer LM (2004). Developing understanding and social skills through cooperative learning. J. Sci. Math. Educ., Southeast Asia, 27(2): 45-80.

Fraenkel JR, Wallen NE (2000). How to Design and Evaluate Research in Education. 2nd Edition. New York. NY: McGraw-Hill Companies Inc.

George PG (1999). Using Cooperative Learning in the College Classroom. The NEA Higher Educ. J., pp. 33-38. http://www2.nea.org/he/heta99/images/s99p33.pdf.

Gödek Y (2004). The Development of Science Education in Developing Countries. G.Ü. Kirşehir Eğitim Fakültesi Dergisi, Cilt 5, Sayı 1: 1-9. http://www.kefad.gazi.edu.tr/2004.1/1-9.pdf.pdf.

Government of Kenya (2003). National Atlas of Kenya. Fifth Edition. Nairobi. Survey of Kenya.

Government of Kenya (2005). Kenya Education Sector Support Programme 2005-2010; Delivering quality education and training to all Kenyans. Ministry of Education, Science and Technology. Nairobi.

Government of Kenya (2007). Kenya Vision 2030. Government Printers. Nairobi.

Ho FF, Boo HK (2007). Cooperative Learning; Exploring its Effectiveness in the Physics Classroom. Asia-Pacific Forum Sci. Learn. Teach., 8(2): 1

Hopkins, K.D. (1998). Educational and Psychological Measurement and Evaluation. 8th Edition. Needham Heights. MA. Allyn and Bacon.

Institute of Biology (2007). Annual Report 2007. http://www.iob.org/userfiles/AR_www.pdf.

Institute of Biology (2008). A response from the Institute of Biology to the Environmental Audit Committee Inquiry: "Greener towns for the future?" London. http://www.iob.org/userfiles/Ecotowns%2025Apr2008.pdf.

International Association for the Evaluation of Educational Achievement (1997). Third International Mathematics and Science Study. Center for the study of testing, evaluation and educational policy. Boston College, Chestnut Hill, MA, USA.

Johnson DW, Johnson RT (2003). Implementing Cooperative Learning. Educ. Digest, 58(8): 62-66.

Johnson DW, Johnson RT, Holubec EJ (1994). Cooperative Learning in the classroom. VA. Association for Supervision and Curriculum Development.
Karen BS (2008). Biology and Society: A New Way to Teach Tertiary Science to Non-science Students. Biol. Educ. J., p. 12. http://www.bioscience.heacademy.ac.uk/journal/vol12/beej-12-c4.pdf
Kenya Institute of Education (2002). Secondary Education Syllabus Volume Two. Kenya Institute of Education, Nairobi.
Kenya National Examination Council (2005). 2004 KCSE Examination Report. KNEC, Nairobi.
Kenya National Examination Council (2005). Kenya Certificate of Secondary Education; Regulations and Syllabuses 2006-2007. Kenya National Examination Council, Nairobi.
Kenya National Examination Council (2006). 2005 KCSE Examination Report. KNEC, Nairobi.
Kenya National Examination Council (2007). 2006 KCSE Examination Report, KNEC, Nairobi.
Kenya National Examination Council (2008). 2007 KCSE Examination Report. KNEC, Nairobi.
Kolawole EB (2008). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. Educ. Res. Rev., 3(1): 033-037.
LaCarrubba A (1993). A comparative study of the academic achievement of primary students when learning science through the directed reading activity or cooperative learning approach. Unpublished Dissertation for Masters of Arts Degree in Education. Kean College of New Jersey.
Liang LL, Gabel DL (2005). Effectiveness of a Constructivist Approach to Science Instruction for Prospective Elementary Teachers. Int. J. Sci. Educ., 27(10): 1143–1162. Philadelphia, PA, USA.
McDowell GR (2001). A student-centred Learning Approach to Teaching Soil Mechanics. Int. J. Eng. Educ., 17(3): 255-260. Great Britain. TEMPUS Publications. http://www.ijee.dit.ie/articles/Vol17-3/Ijee1191.pdf.
Ministry of Education (2001). National Report on the Development of Education in Kenya presented at the International Conference on Education 46th session, Geneva, 5-7th September. http://www.ibe.unesco.org/International/ICE/natrap/Kenya.pdf.
More G, Flowers J, Abu RB (1992). The Effects of Cooperative Learning Methods on Achievement, Retention, and Attitudes of Home Economics Students in North Carolina. North Carolina State University. http://www.cals.ncsu.edu/agexed/people/moore/82p.pdf
National Research Council (1995). National Science Education Standards. Washington D.C. National Academy Press.
OECD-PISA (2003). Learners for Life; Student Approaches to Learning Results from PISA 2000. OECD, Paris.
OECD-PISA (2004). First Results from PISA 2003; Learning for Tomorrows World. OECD. Paris.
Ogbo O (2004). Can Africa Develop without Science and Technology; Techno policy Brief 9. African Technology Policy Studies Network (ATPS). Nairobi.
Robson C (2002). Real World Research; A Resource for Social Scientists and Practitioner- Researchers. Second Edition. Malden. MA. Blackwell Publishing.
Slavin RE (1995). Cooperative Learning: Theory, Research and Practice. Allyn and Bacon, Boston.
Staver JR (2007). Teaching Science. International Academy of Education. UNESCO. Imprimerie Nouvelle Gonnet, 01300 Belley, France.
UNESCO (2004). Report on Development of Education in Kenya: Ministry of Education Science and Technology. UNESCO-Nairobi Office. http://www.ibe.unesco.org/International/ICE47/English/Natreps/reports/kenya.pdf.
UNESCO (2000). World Education Forum: The Dakar Framework for Action, Education for All: Meeting our Collective Commitments. UNESCO, Paris.
UNESCO (2005). Global Monitoring Report; Education for All, the Quality Imperative. UNESCO, Paris.
Wachanga SW, Mwangi JG (2004). Effects of the Cooperative Class Experiment Teaching Method on Secondary School Students' Chemistry Achievement in Kenya's Nakuru District. Int. Educ. J., 5(1): 26-36.
Wambugu PW, Changeiywo JM (2008). Effects of Mastery Learning Approach on Secondary Students' Physics Achievement. Eurasia J. Math. Sci. Technol. Educ., 4(3): 293-302.
Wiersma W (2000). Research Methods in Education: An Introduction. Needham Heights. M.A. Allyn and Bacon.
Zafer T, Mustafa E (2008). Effects of Cooperative Learning on Instructing Magnetism: Analysis of an Experimental Teaching Sequence. Latin America J. Phys. Educ., 2(2): 124-136. http://www.journal.lapen.org.mx/may08/LAJPE%20166F%20Zafer%20Tanel.pdf.