Effectiveness of e–Learning Investigation Model on Students' Understanding of Classification of Organisms in School Biology

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Abstract

A recent report revealed that students' understanding in secondary school biology has been generally poor due to inappropriate teaching and learning approaches employed in the instructional process. It indicates that several science teachers in Rift Valley Province ranked the topic of classification of organisms as the second most difficult area that the regular methods are weak in making students understand it. In response, the study reported here investigated the effectiveness of E-Learning Group Investigation Model (ELGIM) intervention on form three students' biology learning outcomes. ELGIM is a combination of e-Learning (EL) and Collaborative Learning (CL) instructional strategies employed to curb this problem. The study was based on the topic classification of organisms undertaken over a period of 8 weeks with 165 form three pupils from four secondary schools in Nakuru district, Kenya. A Solomon-four quasi-experimental design was carried out to investigate the effects of ELGIM on students' understanding and attitudes on their pre- and, post-, Achievement Test, Attitudes questionnaire Dependent measures. Two control groups C_1 (N=100) that received the pre-test and C_2 which did not received conventional instruction whereas two experimental groups E_1 (N=111) that was pre-tested and E_2 (N=) which did not received their instruction via the mode. All groups were exposed to the same classifications of organisms syllabus except for the instructional methods used. Data was collected using two instruments namely; the Biology Achievement Test (BAT) and Students' Attitude Questionnaire (SAQ) used to assess the Biology learning outcomes. This study successfully demonstrates that the experimental group students outperformed the conventional group students in the domains of concept construction, conceptual change and scientific reasoning. Moreover, students with a higher level of scientific reasoning were more able to successfully change their alternative conceptions. It concludes that collaborative learning approach has major implications for teaching difficult topics in science and enhancing students' learning outcomes. Hence, this intervention should be integrated into the existing school science curriculum.

Keywords: Biology instruction, Collaborative learning, e-Learning, School science curriculum, Secondary education

1. Introduction

The importance of Biology in the science curriculum of most countries continues to grow. For instance, Kim, Fisher and Fraser (1999) noted that Biology has increasingly become a mandatory subject during the elementary years in school in most developed countries. Webb (2010) asserts that it is more important that all citizens understand the ways of science and how the actions of society affect living things. Considering this, an understanding of the nature of science and fundamental biological concepts is critical for any person regardless of his/her vocation. School Biology is a demanding science subject to teach and learn not only because living systems are so complex but also because it incorporates concepts from Chemistry, Physics and Mathematics. Moreover it plays an important role and affects many aspects of human life that requires a good grasp of the basic principles of Biology and their application to real life situations. It is also a practical subject meant to equip the learner with skills that are necessary for solving the daily problems in life. Therefore Biology instruction at the secondary level should prepare learners to deal with the contemporary environmental challenges in society by providing them with the necessary knowledge with which to control or change the environment for the benefit of human life (Kenya Institute of Education [KIE] 1999). As such, the teaching of the concept of classification of organisms is critical at the commencement of secondary school Biology.

A recent study revealed that most secondary school teachers still expect their students to accumulate biological knowledge by engaging them in limited activities in the form of illustrative and expository sessions used to prove theories (Kiboss, Wekesa & Ndirangu, 2006). However, this expository teaching that has continued to dominate the instructional practice in the majority of our schools is weak and if left unabated, it will continue to exacerbate the problem (Kiboss, 2000). Nevertheless, our schools may benefit from the inclusion of collaborative learning (CL). CL is an instructional strategy that has been lauded for its prowess to change the traditional teacher–as–information–giver and textbook guided classroom style that is common in most of our science instruction (Kiboss, 2002). It is based on the Vygotskian theory which implies that the formation of the mind as an essentially inescapable socio–cultural process (Cobb & Yackel, 1996; Lorsbach & Tobin, 1992; Vigotsy, 1978).

The importance of including collaborative learning in this study is two–fold– first is that studies suggest that learning is fundamentally influenced by the context and activity in which it is embedded (Cecez–Kecmanovic & Webb, 2000; Chung, 1991; Williams 2007) and secondly, the prime goal of education is to educate and socialize children into becoming functional citizens (KIE, 2002). This was also considered relevant because most of the socio–cultural contexts where our pupils find themselves involve interactions and activities that require their collaborative efforts. Besides, an African child whether in or out of the classroom is hardly alone, but is usually in the company of other persons (Kiboss, 1997).

The basic assumption for including CL is that science instruction in our schools often occurs in learning environments that are collaborative in nature. As such, our pupils need effective collaborative models in order for them to make valid scientific predictions about what will happen independently of their actions and to act on the environment in a purposeful way (Kiboss, 2000). It is also based on the belief that the creation and transmission of knowledge can effectively be approached as a genuinely collective enterprise that is inextricably embedded in the on–going system of shared activity. Here, learning is enhanced in two ways – first by generating individual and shared knowledge, and second by accumulating and transmitting shared knowledge. Since learning is inherently social, CL has as its main feature a structure that allows for student talk and the more they do so the more that much of the learning occurs. In other words, it produces an intellectual synergy of many minds coming to bear on a problem, and the social stimulation of mutual engagement in a common endeavor (Golub, 1988; Kiboss, 2000). It is this mutual exploration, meaning–making, and feedback that often helps pupils to better understand and to create new understandings for all learners (Ogunniyi, 1998; Roth & Roychoudhury, 1992; Tobin, 1997).

According to Johnson and Johnson (2000), Group Investigation is model in which groups take tasks on topics within a unit studied by the whole class and then subdividing each topic into tasks distributed among members of the group and each pupil investigates his/her subtopic individually and ultimately presents findings to the whole class. This model has been found beneficial for improving pupils' achievement. In this study, the Group Investigation was combined with the electronic learning (EL) which is a kind of instruction where the computer is incorporated as part of a visual learning environment for the purpose of presenting and explaining difficult concepts using animations and graphical display capabilities inherent in the computer (Kanuka, 2007; Lehtinen, 2003 & Lipponen, 2002).

The study is based on the assumption that the learners are able to shift from the cognitive focus of knowledge structures presumed in their mind to a constructivist focus in which they take an active participation in the social context. As such, the classroom culture was assumed to shift away from the usual teacher obsession of knowledge reproduction common in most third world science classroom environments to classrooms enriched with electronic learning environments that are capable of mediating knowledge building and social exchanges among peers as active participants in discourse communities (Bonk, Medury & Reynolds 1997, Fabos & Young, 1999, Kiboss 2000).

Thus, the marriage of Group Investigation and e-learning was employed with the expectation that it would open opportunities for learners to interact with multiple perspectives, which challenge their existing knowledge constructions and impose cognitive conflicts that require their negotiations, hence improved learning (Cobb & Yackel 1996; Kanuka, 2007; Lehtinen, 2003 & Lipponen, 2002). While such a combination learning approaches as an instructional strategy may be applied as an intervention to improve the pupils' learning of classification of organisms and their attitudes towards Biology, no data is available to support its effectiveness or otherwise. Therefore the object of this study is to contribute in this regard.

1.2 Theoretical Construct

This study was based on the integrative theory of collaborative learning and achievement developed by Slavin (1989) on six complementary theoretical perspectives with well established rationales as shown diagrammatically below.

Figure 1[Here]

According this model, individual learning of all group members is assumed to directly affect the cognitive processes by motivating learners to engage in group goals (peer modeling, cognitive elaboration, and practice). Such motivation in group goals also lead to group cohesiveness, increased care and concern among learners, hence making them feel responsible for one another's achievement. Finally, learners are motivated to take responsibility for one another independently of the teacher and thereby solve important classroom organization problems and in the process provide increased opportunities for cognitively appropriate learning activities that may in turn lead to enhanced/improved learning.

1.3 The Problem

Globally, there is a new view of science driven partly by the needs of a changing economy and a research on learning and cognitive science calling for the need to help learners develop various skills (e.g. higher–order abilities, problem solving and thinking abilities) necessary for them to construct knowledge wisely, fluently and flexibly in interactions with novel experiences (Kiboss 2000, 2002). However, this view is opposed to the expository methods commonly seen in our science instruction classrooms; which in itself ineffective and unable to empower the learner to move away from the practice of knowledge production of verbal answers on cue to that of integrating the complex structure of scientific knowledge. This shift is critical in that the learner is required to make use of scientific ideas, compare relationships between the ideas and reasons for these relationships, explore ways to use them to explain and predict other natural phenomena and to eventually apply them in novel situations (Kiboss, 2002; Roth & Roychoudhury, 1992).

Apparently, the continued use of such an approach in science instruction cannot inculcate the learner's active participation in the instructional process. Instead, it may exacerbate the current problem of the teacher's failure to empower the learners to develop the necessary understanding of scientific knowledge, skills and attitudes especially in the teaching the topic of classification of organisms in school Biology in Kenya. This topic is a foundational and compulsory course in Biology education and was ranked the second difficult area in need of a different approach that the regular one by 19 science teachers from Rift Valley Province in Kenya (Kiboss 1997). Nevertheless, this problem facing Biology instruction at the secondary level may be arrested by the use of modern powerful e-learning environments capable of enhancing pupils' understanding of science topics considered difficult to teach using the traditional method (Kiboss 2011, Kiboss 2006; Kiboss, Wekesa & Ndirangu 2005).

The object of this study is to employ the use of Group Investigation Model of collaborative learning and e-learning environments that have been lauded as capable of empowering learners to interactively participate and grow during the learning process as a means to increase their potentials in science instruction, particularly in the teaching of Biology areas that have been identified as in need of different approaches. Thus, the study reported in this paper is an attempt to investigate the effectiveness of ELGIM to enhance pupils' understanding of classification of organisms and attitudes toward Biology.

1.4 Research Questions

In order to achieve this objective, answers were sought to the following questions:

1) What is the effect of ELGIM in enhancing pupils' understanding of classification of organisms in school Biology?
2) What is the effect of ELGIM pupils' attitude towards classification of organisms in school Biology?
3) Is there any significant difference between the understanding of classification of organisms of pupils exposed to ELGIM and those not so exposed?
4) Is there any significant difference between the attitudes towards classification of organisms in school Biology of pupils exposed to ELGIM and those not so exposed?

2. Methodology

2.1 ELGIM Program

The ELGIM program developed consisted of twenty two basic lessons covering eighteen classification of organisms (binomial nomenclature and general principles of classification, division of phycophyta, division of mycophyta, division of brycophyta, division of pteridophyta, the animal kingdom (kingdom animalia), phylum protozoa, phylum porifera, phylum coelenterate, phylum platyhelminthes, phylum nematode, phylum anelida, phylum echinodamata and mollusca, phylum arthropoda, phylum chordata, and the dichotomous key). These topics were extracted from the primary school syllabus recommended by the Kenya Institute of Education (KIE, 2002) to be taught to learners during the school term.

During the initial stages ELGIM underwent two major reviews. First, three computer–based education (CBE) experts knowledgeable in science education reviewed it. The purpose of this was to assess the overall quality of the first version in terms of language and grammar, surface features, questions and menus. The suggestions for modification were considered and were deemed appropriate. Second, the modified version was again subjected to another review by six educational technology and science education experts (two educational technology lecturers, two secondary science department heads and two secondary school physics teachers) knowledgeable in science education at the secondary level in Kenya. This was meant to solicit comments and feedback on the quality of ELGIM before it was finally piloted on a group of secondary school student–helpers who did not participate in the actual study.

The ELGIM courseware was authored using the Multimedia Builder, object–oriented programming software for microcomputers developed by Roman Voska in 2002. The software was considered appropriate due to its capability to combine text, graphics, and animation display editors during the authoring process (Engler, Jeschke, Ndjeka, Sieler, & Steinmuller 2006, Kanuka, 2007).

2.2 Research Design

The research design adopted for this study is the Solomon–Three Group Quasi–Experimental Design, which is considered sufficiently rigorous and appropriate for experimental and quasi–experimental studies (Fraenkel & Wallen 2006; Ogunniyi, 1992). The design involves a random assignment of participants to three groups with two groups taking the pretest and one not. This design was adopted because the participants of the study had already been constituted and it was not possible to randomly select them individually for experimental purposes. Moreover, Kenyan school authorities do not normally allow a random assignment of individual pupils once they are constituted.

This design was also chosen because it could provide adequate control of the extraneous variables that would have affected the internal and external validity of the study (Cohen, Manion & Morrison 2007). Contamination was addressed by having the treatment and control groups situated in different schools while the statistical regression was taken care of by having another group of participants not taking the pretest.

In this design, two groups served as the experimental group I (E_1) and experimental group II (E_2) with the former receiving the pretest variable and the latter withheld but both receiving the treatment. Two others served as control groups – one which received the pretest measure to serve as the true control group I (C_1) and the other as control group II (C_2) because it was not pretested. All groups were exposed to the same course content on classification of organisms with the experimental group using ELGIM and the control group the regular method. They were posttested after the course was terminated.

2.3 Participants

In this study, provincial mixed secondary schools in Nakuru district, Kenya were selected on the basis of willingness to participate and accessibility by the researcher. A total of 165 participants, 80 girls and 85 boys, took part in the study. All the 165 pupils were exposed to the same 12 lessons content on classification of organisms in school biology over a period of four weeks (KIE 2002). The experimental groups (E_1 and E_2) received their lessons through the ELGIM program while the control groups (C_1 and C_2) through the conventional or regular teacher directed methods.

2.4 Instruments

The variables of interest reported are pupils' understanding and attitudinal change. Understanding was taken to mean the level of learning exhibited by the participants' achievement on pretests and posttests on classification of organisms measured using the Biology Achievement Test (BAT) instrument, which consisted of 30 test items developed to assess pupils' understanding on the concept of classification of organisms in school biology. A field test of this instrument yielded a reliability coefficient of 0.864 using the Kuder Richardson 21 (KR–21) formula which is considered acceptable for experimental purposes.

The attitudinal change focused on students' attitude towards school Biology. This was measured using the Students' Attitude Questionnaire (SAQ) adopted from Kiboss (1997) and modified to suit the study. The piloting of the instrument yielded a Cronbach alpha coefficient reliability of 0.771 which is considered acceptable for research purposes (Fraenkel & Wallen, 2006).

3. Results and Discussion

In this section, the findings of the effect of the ELGIM program on the students' (a) understanding of classification of organisms as measured by BAT and (b) attitudinal change towards classification of organisms as measured by SAQ are presented and discussed.

3.1 Effects of ELGIM on Students' Understanding of classification of organisms

The participants' comparative results of their performance on the BAT shown in Table 1 indicates that prior to the commencement of the biology course on classification of organisms, the participants were equal because the mean scores (M=25.97 and M=26.09) and the standard deviations (SD=11.03 and SD=10.09) for the E_1 and C_1 groups that received the pretest were similar. However, after the commencement of the course, the mean gain (21.48) of the participants in the experimental group (E_1) was higher than that (15.35) of their counterparts in the control group (C_1).

Table 1[Here]

It is also notable from the results in Table 1 that after the commencement of the course, the mean scores

(*M*=48.45 and *M*=48.23) obtained respectively by the two groups (E_1 and E_2) that learned classification of organisms through the ELGIM in the posttest were not only similar but higher than those (41.44 and 43.99) of the C_1 and C_2 respectively. An ANOVA test performed to determine whether the performance of the participants learning in classification of organisms through ELGIM and those using the regular program was statistically significant. The data is presented in Table 2 below.

Table 2 [Here]

The ANOVA results presented in Table 2 yielded an *F*–ratio of $F(3,167) = 9.032$, $p<0.05$, which is indication that the performance of the participants in the ELGIM program is statistically significant at 0.05 level. This finding is supported by the Least Significant Difference (LSD) figures shown in Table 3 that portrays a trend – $E_1 = E_2 < C_1=C_2$. This is an implication that the performance of the participants in the ELGIM experimental condition (E_1 and E_2) on posttest BAT is similar but that between ELGIM groups (E_1 and E_2) and control groups (C_1 and C_2) is statistically significant at the 0.05 level in favour of the ELGIM group. The data shown in Table 3 attests to this fact.

Table 3 [Here]

The figures shown in Table 3 indicate that the mean difference (3.630) between the experimental groups (E_1 and E_2) that received the ELGIM treatment is not statistically significant. The same case applies to the mean difference (3.122) between control groups (C_1 and C_2) that did not receive ELGIM. However, the mean differences (12.129) between the E_1 and C_1 group as well as that (15.252) between E_1 and C_2 is statistically significant at $p<0.05$.

It is therefore safe at this juncture to conclude that the higher performance evident with the statistically significant mean differences observed in favor of the participants in the treatment group is not unrelated to the use of the ELGIM program in which they were exposed. Thus, the null hypothesis suggesting that use of ELGIM program will have no significant effect on the participants' understanding of classification of organisms in school biology was therefore rejected.

3.2 Effect of ELGIM on Students' Attitude towards Biology

The impact of ELGIM on the participants' affective outcomes was measured using the Students' Attitude Questionnaire (SAQ) and analysed using the ANOVA.

Table 4[Here]

The data presented in Table 4 shows that the mean scores obtained by the participants in the E_1 group (M=67.06) and the C group (M=67.01) before the Biology topic on classification of organisms were similar. But after the commencement of the topic, the pupils in the ELGIM program (E_1 and E_2) outscored their counterparts in the control condition in that their posttest mean scores (M=80.54 and M=80.63 respectively) were higher than the mean scores (72.69 and 73.44) obtained respectively by the control (C_1 and C_2) groups. Moreover, the group mean gain (13.48) obtained by the E1 group that was pretested is much higher than that (5.35) of the true control group as well as that (9.62) obtained by both groups combined.

Table 5[Here]

An ANOVA test performed to determine the difference in mean scores between the ELGIM treatment groups and the control groups yielded an F value $F(3, 167) = 8.993$; $p<0.05$. This finding was also confirmed by the Least Significant Difference (LSD) post hoc test results that showed that the pupils in the ELGIM program had not only similar effects but the posttest mean differences were both significantly greater than those of the pupils in the control condition. This is a clear indication that the participants in the ELGIM program performed significantly better on the PAQ than those taught through traditional methods.

These findings seem to support the current notion that the use of the ELGIM to augment conventional science instruction might lead to massive effects. Besides, this study is not only innovative but has provided empirical evidence documenting how ELGIM impacts on the teaching and learning of school science. It has also supported earlier findings in the area indicating that the use of the new media such as ELGIM has the potential of improving learning in a variety of areas (Cecez–Kecmanovic, Webb 2000; Williams 2007).

4. Conclusions and Implications

In this paper, an attempt has been made to use the results of the study to corroborate or falsify the hypotheses posited for testing with regard to effects of ELGIM on pupils' achievement and attitudinal change towards classification of organisms. The idea that an exposure of the pupils to the ELGIM would have no significant effect on their achievement and attitudes towards classification of organisms was rejected. This finding is consistent with several related studies suggesting that use of well–designed electronic learning programs enhances communication in the classroom during science learning (Kiboss 2000, 2002, 2011). Similarly, it corroborates Wekesa (2003) and Kiboss et al. (2006) findings which established that the use of e-learning improves the learning of Biology, especially cell theory.

Apparently, the findings of the study regarding the effects of ELGIM's capability to enhance the pupils' understanding and attitudes towards classification of organisms in school Biology were in the affirmative. In other words, the study demonstrated that a well–designed collaborative electronic learning program can be used effectively to improve the pupils' achievement in the topic of classification of organisms in school Biology and to boost their attitudinal change. In this study, however, only the ELGIM and expository teaching approaches undertaken in Kenyan secondary schools contexts were compared.

However, the results have shown that the ELGIM program was an effective instructional method in the Biology classroom milieu which was not just effective in the attainment of better results than the conventional mode of instruction but can also serve to ameliorate the instructional problems associated with the learning of difficult areas in science instruction. Therefore, the study recommends that ELGIM programs should be made part of classroom instruction to help teachers speed up and improve the delivery of concepts and lesson content in science learning. This is because electronic learning programs when combined with collaborative learning strategies are capable of providing interesting and effective learning environments.

The findings of this study therefore have implications for the teaching of school Biology. For instance:

1) ELGIM adds a new hybrid learning strategy to the instruction of school Biology and can supplement the traditional methods of instruction which are mainly exposition oriented.
2) This study established that the method improves pupils' achievement when used in collaborative classroom instruction. This is significant considering our need to improve understanding of classification of organisms in school Biology which is considered difficult to teaching using the regular method.
3) ELGIM programs make pupils discussion group during learning easy by presenting information in a manner that is more appealing and easy to comprehend by all community learners. Concepts are visually presented in text and graphical format to ease encoding, processing, storage and retrieval of information, thereby quickening the learning process.
4) ELGIM, apart from introducing a new hybrid mode of instruction that is both interesting and motivating to the learners compared to the expository method prevalent in our regular classroom instruction, improves achievement and offers learners a means through which they can attain higher scores and further their education in science.

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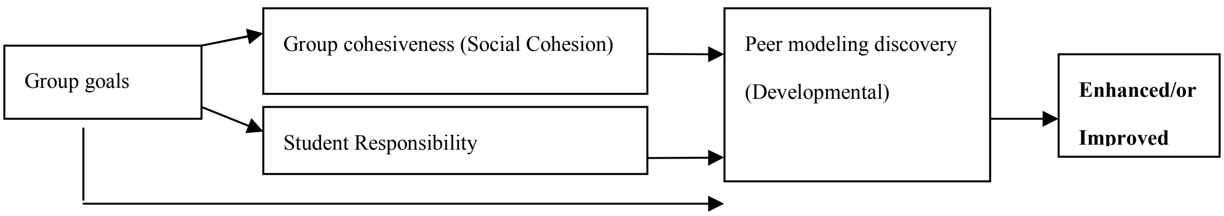

Figure 1: Relationships among the six perspectives on collaborative learning

Table 1: Comparison of BAT Pretest and Posttest Mean Scores

		GROUP			
Scale	Overall (*n=165*)	E_1(*n=39*)	E_2(*n=41*)	C_1(*n=45*)	C_2(*n=40*)
Pretests mean	26.03	25.97[a]	–	26.01[a]	–
S.D	10.44	11.03	–	10.85	–
Posttests mean	45.53	48.45[b]	48.23[b]	41.44	43.99
S.D	16.21	15.43	16.73	12.17	12.94
Mean Gain	19.50	22.48	–	15.43	–

[ab] denotes similar mean scores

Table 2: Results of ANOVA on the BAT

Source	SS	*df*	MS	*F*	p–value
Between groups	6067.466	3	2022.489	9.032*	0.000
Within groups	35157.652	164	223.934		
Total	41225.118	167			

*significant at 0.05 level

Table 3: Least Significant Difference Post Hoc on BAT

LSD for Four Groups (I) Group		**(J) Group**	**Mean Difference (I–J)**	***P*–value**
E_1	vs	E_2	3.630[ns]	0.286
		C_1	12.129*	0.000
		C_2	15.252*	0.000
E_2	vs	E_1	–3.630[ns]	0.286
		C_1	–8.499*	0.000
		C_2	11.621*	0.000
C_1	vs	E_1	12.129*	0.000
		E_2	8.499*	0.000
		C_2	3.122[ns]	0.343
C_2	vs	E_1	15.252*	0.000
		E_2	11.621*	0.000
		C_1	–3.122[ns]	0.343

* significant $p<0.05$; ns not significant

Table 4: Comparison of SAQ Mean Scores, S.Ds and Mean Gains

		GROUP			
Scale	Overall (*n=165*)	E_1 (*n=39*)	E_2 (*n=41*)	C_1 (*n=45*)	C_2 (*n=40*)
Pretests mean	67.20	67.06[a]	–	67.01[a]	–
S.D	8.82	8.03	–	8.60	–
Posttests mean	76.82	80.54[b]	80.63[b]	72.69	73.44
S.D	9.62	9.24	9.73	10.17	10.21
Mean Gains	9.62	13.48	–	5.35	–

[ab] denotes similar mean scores

Table 5: Results of ANOVA on SAQ Posttest Mean Scores

Source	*SS*	*df*	*MS*	*F*	*p–value*
Between groups	5028.208	3	2012.467	8.993*	0.000
Within groups	19640.92	164	221.94		
Total	41218.111	167			

*significant at 0.05 level