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Research Article

Understanding the bottlenecks in methodological adoption of constructivism in secondary schools in Kenya

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ABSTRACT

Constructivist teaching and learning approach is one of teaching approach gaining popularity based on its principles of learner centered education. This study investigated the effectiveness of constructivist method of instruction on learning biology and challenges facing its implementation in secondary school students. The study design was quasi-experimental non-equivalent groups with a post-test examination. A total sample participated in this study was 477 students and 12 teachers. The instruments used in this study were; constructivist instruction manual, post-test, attitude questionnaire, and teacher's questionnaire. The data collected was analyzed descriptively using mean and standard deviation values, while t-test and ANOVA were used to test the differences between group means at α=0.05 level. The study established that constructivist method of instruction was more effective in learning biology compared to conventional methods. Moreover, the both positive learner and negative teacher attitudes toward the application of constructivism was found as considerable as inadequate compulsory facilities in the implementation of constructivist learning approach. Thus, it is recommended to conduct deliberate programs in implementing constructivist learning approach in secondary schools in Kenya.

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INTRODUCTION

Teaching and learning biology in many secondary schools in Kenya has generally taken a pattern where teachers mostly use instructional methods characterized by lectures and few demonstrations (Gideon M. Mwanda, Paul Odundo, Ronnie Midigo, & Owino S. Mwanda, 2016; Mukhwana, 2016; Ngesu, Gunga, Wachira, & Kaluku, 2014; Nyongesa, 2015; Ouko, Anditi, & Githua, 2017; Vidija, 2015). These instructional methods expose students to minimal practical activities, group discussions, and are hardly taken on educational trips

(Allybokus, 2015; Jepketer, 2017; Jidamva, 2012). Consequently, learner achievement in biology has been poor.

On the other hand, an application of learner-centered instructional approaches has a greater potential in enhancing learner achievements (Andersen & Andersen, 2017; Connell, Donovan, & Chambers, 2016; Hsu, Wang, & Levesque-Bristol, 2019; Izzo, 2012; Kharb, Samanta, Jindal, & Singh, 2013; Laal, Naseri, Laal, & Khattami-Kermanshahi, 2013; McKnight et al., 2016; Montrieux, Vanderlinde, Schellens, & De Marez, 2015; Öhrstedt & Lindfors, 2018; Zenda, 2017). This study considered application of constructivism as espoused by Piaget and Inhelder (1964) in teaching and learning Biology for better learner achievements. This approach is herein referred to as individual constructivist theory.

Individual constructivist theory of Piaget and Inhelder (1964) provides a two-pronged approach to knowledge construction. First, Piaget's cognitive structures (schema) which responsible for adaptation processes of assimilation, accommodation and equilibrium are like use of prior-learning experiences in aiding new knowledge constructions. Second, learning occurs when an individual pass through four stages of cognitive developments: sensory-motor, pre-operational, concrete and formal operational stages. Concrete and formal operational stages are implied in constructivist learning. At the concrete stage, learning is by manipulating objects, ideas, and events which later are transformed to formal reasoning. In constructivist learning, repeated manipulation of objects and ideas enables learners to construct meaningful concepts that can be transferred to logical abstract reasoning in a formalized manner.

The social constructivist learning theory proposed by Vygotsky in 1978, considered learning as a socially mediated exercise where a person constructs his/her knowledge based on his/her interactions with social and cultural environment (Hakkarainen, Paavola, Kangas, & Seitamaa-Hakkarainen, 2015; Shabani, 2016; Shabani, Khatib, & Ebadi, 2010; Thomas, Menon, Boruff, Rodriguez, & Ahmed, 2014; Verenikina, 2010; Vygotsky, 1978; Wang, Bruce, & Hughes, 2011). Knowledge formed by a learner is influenced by environment (context) and prior knowledge held by the learner (Jang, Kim, & Reeve, 2016; Kimmerle, Moskaliuk, Oeberst, & Cress, 2015; van Riesen, Gijlers, Anjewierden, & de Jong, 2018). Therefore, in social constructivist learning, teachers should provide learners with opportunity to negotiate meaning and to collaborate with peers and adults including teachers in knowledge construction (Adams, 2006; Jafari Amineh & Davatgari Asl, 2015; Jang et al., 2016; Lai, 2011; Mensah, 2015; Piaget & Inhelder, 1956).

Based on the advantages mentioned above, however, the evaluations of constructivist approach adopted in Kenya are still limited. Thus, the 5E's (Engage, Explore, Explain, Elaborate, Evaluate) constructivist was adopted in this study, a social constructivist approach in learning activities, was applied to provide learners with opportunities in constructing knowledge at individual and social levels during group discussions. In sense of assessing the effectiveness of constructivist instructional approach on learning biology as well as comprehending the challenges faced as its implementation in secondary school.

METHOD

This study was quasi-experimental non-equivalent group with post-test design. Both teachers and biology learners were the study population and examined in ecology topic. The participants in the study were divided into two groups i.e. experimental and control groups. The experimental group was exposed with constructivist instructional approach, while the control group was taught in conventional instructional method. A total of 477 students and 12 teachers were sampled to participate in this study. Research data were collected using post-test as well as a structured questionnaire. The all data collected were analyzed using both descriptive (mean and standard deviation) and differential statistics (t-test at α=0.05 level).

RESULTS AND DISCUSSION

Comparing constructivist and conventional instruction

In attempting to investigate the effects of constructivist and conventional instructional approaches on learning biology, the post-test results gained in the both groups were analyzed and compared. This analysis was conducted in two ways: first, the total of post-test results for all participants in the both groups were analyzed and compared using descriptive statistics as well as t-test to observe whether there was a significant difference between the two groups. The analysis results are served in Table 1. Second, post-test results of the two groups were also analyzed and compared based on six cognitive levels.

Table 1. Posttest results for the constructivist and conventional groups

Instructional group	Number of candidates	M	SD	*t*-test	*p*-value
Constructivist	231	45.84	15.05		
Conventional	246	40.26	13.96	4.17	0.001

The results in Table 1 indicate that the participants in experimental group (M = 45.84, SD = 5.05) performed significantly better over their peers in the conventional group (M = 40.26, SD = 13.96), $t(475)=4.17$, $p<.001$ in which the alpha level of .05.

The results obtained imply that participants who were exposed to constructivist method of instruction had a better understanding of the information covered during the period of instruction than those who were exposed to conventional methods. In the sense that constructivist instructional approach is more effective in promoting learning (Eilam & Trop, 2012) of biology amongst students at secondary school compared to the conventional one. The assumed undergirding reason of this condition was the various activities conducted in constructivist group had engaged the students during the learning. Not only did the participants in constructivist group make working groups, but they also collaboratively worked on task items once the classes were engaged (Jafari Amineh & Davatgari Asl, 2015).

Discussions, presentations, elaborations, and critique activities that formed key aspects of constructivist instruction enhanced understanding and memory of participants in the constructivist group (Andersen & Andersen, 2017; Connell et al., 2016; Hsu et al., 2019; Izzo, 2012; Kharb et al., 2013; Laal et al., 2013; McKnight et al., 2016; Montrieux et al., 2015; Öhrstedt & Lindfors, 2018; Zenda, 2017). The engagement phase provided learners with opportunity and much needed scaffolding which made them more focused and clearer on how to carry out investigations and what to discuss in the groups. During the discussions, participants constructed their own knowledge and tested it within the groups hence. This provided them a space for immediate feedback and motivation to seek for more information from various possible sources. During elaboration phase, the participants were presented with new tasks. Those tasks were related to what they had learned earlier so that the participants got opportunity to expand their horizons of thought as they reflected on the new tasks.

The idea of teachers building on learners' prior knowledge was similarly elaborated by Powell and Kalina (2009) who recommended that teachers should assist learners to make meaningful connections between prior knowledge and new information. The 5E constructivist model, in this study, provided teachers with opportunity to assist students in constructing connections between prior knowledge and new knowledge experiences which, in turn, can lead them to the better performance in posttest compared to pretest. Powell and Kalina (2009) also recognized the importance of cooperative element in constructivist instructional approach as a way of promoting competition among groups in a class. Thus, providing students with motivation and excitement will lead them to improve their performance. In a similar way, Lord (1999) explained the superiority of constructivist instructional approach over the traditional one on its chances in allowing group discussion and interaction. As the consequences, the positive interdependence formed among students with individual accountability resulted the better learning outcomes.

This study also compared the effects of the two instructional approach on learning biology in the six cognitive levels classified by Bloom (2000). Table 2 presents the posttest analysis results of the both constructivist and conventional groups. The results in Table 2 indicates that participants who experienced the constructivist instructional approach (experimental group) enacted the higher scores in four levels i.e. knowledge, comprehension, application, and evaluation levels compared to those who were exposed with conventional instructional approach (control group). The t-test analysis results show the significant differences in cognitive domain levels between the two groups. T-test results of the aspects observed were: Knowledge, $t(475) = 4.19$, $p < 0.001$; Comprehension, $t(475) = 5.36$, $p < 0.001$; Application, $t(475) = 4.78$, $p < 0.001$; and Evaluation, $t(475) = 3.00$, $p < 0.003$. Notwithstanding that four of the six aspects measured indicated that the experimental group levels were higher, but, contrarily, the two remain aspects, analysis (M = 60.33, SD = 23.37), $t(475) = 0.09$, $p <0.93$ and synthesis (M = 63.41, SD = 28.69), $t(475) = 3.02$, $p < 0.003$ levels of control group were better compared to the experimental group (Analysis (M = 60.13, SD = 23.69); Synthesis (M = 55.45, SD = 29.08)). These results revealed that the analysis performance between control group and experimental group was insignificant; meanwhile, the synthesis ability was significantly different in favor of the control group.

The results presented in Table 2 show a decrease trend of students' achievement score from the lowest cognitive level (knowledge) to the highest one (evaluation). In the other words, the higher the cognitive level,

the more difficult the cognitive level to be enacted by students. Even though this common phenomenon occurred, however, the students' ability in analyzing as well as synthesizing were defied the trend. The both cognitive levels were achieved better by participants compared to the other lower cognitive levels. It is assumed that the phenomena is accordance with Lake Wobegon effect (Thorndike, R. M., & Thorndike-Christ, 2010). Lake Wobegon effect is an attempt to explain causes of inflation of a test result based on experience of participants before taking a test. In this study, either the biology teachers revised with participants' some items like items four and five in the posttest or the participants' themselves engaged on self-revision of question items on topic ecology before the posttest. This was assumed as the cause which resulted inflated scores for the two items (Analyzing and Synthesizing).

Table 2. Post-test Results for participants at different cognitive levels

Cognitive Levels	Group	M	SD	*t*-value	*p*-value
Knowledge	Exp(n=231)	56.41	31.75	4.189	<0.001
	Control(n=246)	44.67	29.41		
Comprehension	Exp(n=231)	38.57	24.87	5.355	<0.001
	Control (n = 246)	27.23	21.32		
Application	Exp(n=231)	37.45	28.05	4.778	<0.001
	Control (n = 246)	25.73	25.49		
Analysis	Exp(n=231)	60.13	23.69	0.0906	0.928
	Control(n=246)	60.33	23.37		
Synthesis	Exp(n=231)	55.45	29.08	3.023	<0.003
	Control (n = 246)	63.41	28.69		
Evaluation	Exp(n=231)	27.06	28.42	3.004	<0.003
	Control(n=246)	20.16	21.40		

Preferred Instructional Methods for Ecology

Teachers were asked to indicate the instructional methods they preferred. Responses from the twelve teachers who participated in the study are presented in Table 3. From the data served, nine (75%) of the twelve teachers were reported prefer to use the instructional method which involves three components i.e. lecture, students' individual activities, and few practical lessons in the same time. The teachers cited the following three reasons for always choosing the method. One, the method is effective for clear and coherent presentation of ecology concepts and terminologies which are abstract. Two, the method is effective in saving time thus allowing for early syllabus coverage resulting into ample time available for students to carry out revision activities. Three, as their schools are lack of adequate apparatus and equipment for practical lessons, but the method could still allow them to conduct demonstrations. These results might imply that biology classrooms are dominated by direct methods of instruction where teachers have custody of knowledge to be learnt and transmit it to learners who are mostly passive recipients.

Moreover, two (16.67%) of the teachers who participated in this study indicated that they commonly use the methods which accommodates lecture, group activities, classroom discussion, and presentation. There were two undergirding reasons supported the teachers' choice. First, working in groups enables the students to share their learning experiences. As the students' attention and interest are improved, the strong engagement of students' activities will be enacted. They learn what they face during they are immersed in the social area (Hakkarainen et al., 2015). As the consequences, the effective learning is well conducted. Second, group discussion and presentation activities are the two proper ways in improving students' understanding and memories about the materials learned.

Only one (8.71%) of the twelve teachers who implemented the teaching method which involved lecture, note elaborations, and tests. The teacher reasoned that his/her students were slow learners and that there were few biology textbooks in the school. Note elaboration was done during learning process by considering the lack of biology textbooks in the school. Meanwhile, the tests given were utilized as the instruments in drilling the students exercise in solving various questions related to the concepts learned.

Table 3. Preferred instructional methods for ecology

	Instructional Method	Response	Percentage (%)
I	Lecture, elaborate notes and class tests	1	8.71
II	Lecture, Individual activities and few practical lessons	9	75.00
III	Lecture, group activities, class discussion and presentations	2	16.67

Learners' attitude toward constructivism

In order to ascertain the overall attitude of students towards the constructivist instructional approach, the responses from all students who were involved in this study, either as participant in experimental group or the control one as well as they who gave their responses in the attitude questionnaire, were analyzed. The analysis results are served in Table 4. As served in the table, it can be seen that there was a significant difference of female students' response (M = 58.30, SD = 9.15, N = 150) over male students (M = 53.14, SD = 8.24, N=146), $t(294)$ =5.18, p<0.001.

In addition, this finding leads to the conclusion that learners have positive attitude towards constructivist instructional approach. Generally, secondary school students gave more positive responses towards the use of constructivist instructional approach compared to the conventional one. This can be proven by the data which show that the mean of attitude score (measured with attitude questionnaire), the both boys and girls, were more than 50%. This implies that the both female and male students liked to learn in the environment where they get the opportunities to actively participate in constructing their knowledge.

Table 4. Students' attitude towards the constructivist instructional methods

Gender	Mean	Std. Dev.	t-value	p-value
Girls(N=150)	58.3	9.15	5.18	<0.001
Boys(N=146)	53.14	8.24		

Teacher's attitude towards the application of constructivism

Teachers who participated in the study were asked to respond to a set of questions which assessed their attitude towards an application of constructivism in teaching and learning biology. The results are presented in Table 5.

Table 5. Teachers' attitude towards application of constructivism

Teacher's Attitude	SD (%)	D (%)	N (%)	A (%)	SA (%)
Constructivist approach leads to higher learner achievement	28.4	19.6	2	12.3	37.7
Constructivist methodologies can be applied easily in a classroom setting	48.4	17.3	5.9	17.5	10.9
My school support constructivism as a pedagogical approach with enhanced learning	38.6	29.4	1	8.9	22.1
My students enjoy constructivist learning approaches	29.6	13.5	32.3	10.2	14.4
I enjoy applying constructivism in my classes	46.6	18.8	12.6	13.2	8.8

Descriptions: SD (Strongly Disagree); D (Disagree); N (Neutral); A (Agree); SA (Strongly Disagree)

The findings, as served in Table 5, show that teachers were less optimistic toward application of constructivist instructional approach in classroom. Approximately 48.4% of the teachers showed strong disagreement with the statement that 'Constructivist methodologies could be applied easily in a classroom setting'. As to whether students enjoyed constructivist learning environments, 32.3 % were neutral. However, most of the teachers (37.7%), in contrast, indicated strong agreement with the statement that "Constructivist approach leads to higher learner achievement".

Furthermore, 38.6% of the teachers indicated strong disagreement toward the implementation constructivist instructional approach by their respective schools. These finding leads to an understanding that as the teachers were aware about the pedagogical values of constructivism, they rarely applied it in classroom due to inadequacy support as considerable as incompatibility of classroom environments to this approach.

The availability of facilities for teaching and learning ecology

Ecology learning requires practical investigations of the environment to know where exactly the different organisms live. To conduct the effective ecology learning, schools should provide adequate facilities which enable students to carry out the investigations. The facilities considered in this study are basic requirements which mostly needed by students to conduct investigations in school environment (served in Table 6).

The data in Table 6 indicate that schools which participated in the study did not provide the all facilities and equipment needed in ecology learning. The most expensive facility cited in the study was open field ground and apparently all the schools which participated in the study have it. The remaining facilities were of lesser value but were not uniformly possessed by the schools.

Sweep nets and quadrats

Sweep nets and quadrats are key facilities used in carrying out ecological field. It was, therefore, necessary for the study to survey the presence of these two items in the participant schools. Table 7 presents a summary of the number of sweep nets and quadrats in the participant schools.

Data in Table 6 shows that out of the 12 schools which took part in the study, only five (41.67%) were having quadrats, and out of the five schools, three of them had ten quadrats while the other two schools had only two quadrats each. The seven remaining schools (58.3%) did not have even a single quadrat. The data in the table also indicate that eight (66.67%) of the 12 schools had sweep nets and the four (33.3%) remaining schools did not have it.

Table 6. Facilities and Equipment's for teaching and learning ecology

	Facilities and Equipment	Schools Having		Schools Not Having	
		No	%	No	%
1.	Quadrats	5	41.67	7	58.3
2.	Sweep Nets	8	66.7	4	33.3
3.	Open Field	12	100	0	0
4.	Manila or Sisal rope	9	75	3	25
5.	Flip charts or Manila papers	10	83.3	2	16.7
6.	Indelible Ink	8	58.3	4	44.7
7.	Variety of Biology T/books	11	91.7	1	8.3
8.	Panga/Jembe/Shovel	10	83.3	2	16.7
9.	Specimen bottles/Polythene bags	10	83.3	4	16.7
10.	Tape measure/metre rule	12	100	0	0
11.	Cobalt chloride paper	9	75	3	25

Table 7. Sweep nets and quadrats

Number of Quadrats in School	Number of Schools	Number of Sweep Nets in School	Number of Schools
0	7	0	4
1	0	1	2
2	2	2	2
3	0	3	2
4	0	4	0
5	0	5	0
6	0	6	1
7	0	7	0
8	0	8	0
9	0	9	0
10	3	10	1
More than 10	0	More than 10	0

Quadrats and sweep nets are basic facilities used in practical activities to estimate population of organisms. Since these facilities were lacking in many schools or were in scarce quantities in the schools, the implication is that biology teachers are not able to organize for practical lessons or conduct effective demonstration. These findings are supported by KNEC report of year 2007 on KCSE examination.

Challenges encountered during teaching ecology

The challenges discussed here are factors cited by biology teachers who participated in the study (Chin & Osborne, 2008; Feyzioğlu, 2012; Pillay, 2016; Wang, 2014). The factors are considered hindrances to constructivist approach in teaching and learning ecology (Dennick, 2016; Hedden, Worthy, Akins, Slinger-Friedman, & Paul, 2017; Valderrama-Hernández, Alcántara, & Limón, 2017). The all challenges mentioned by the teachers have been summarized into seven points i.e. 1) ecology topic is broad and stressful to teach and cover effectively within the limited time provided by school syllabus coverage deadlines; 2) although ecological field trips are essential in teaching and learning ecology, most of the teachers felt that it is difficult (Allybokus, 2015; Jepketer, 2017; Jidamva, 2012) and expensive to organize; 3) the double lessons allocated for practical activities in the biology time table do not provide adequate time to conduct ecology practical activities (Gideon M. Mwanda et al., 2016; Mukhwana, 2016; Ngesu et al., 2014; Nyongesa, 2015; Ouko et al., 2017; Vidija, 2015); 4) resource materials including variety of biology reference books are either not available in schools or if available, are in inadequate quantities compared to the number of students; 5) frequent interruption of classes or school programs due to fee collection procedures and other school activities resulting in increasing student

absenteeism from classes; 6) terminologies in the ecology topic are difficult so the learners require more time to learn the terms; 7) the time for teaching ecology topic is normally during a dry season when there is inadequate fauna and flora.

This study considered the challenges cited by the biology teachers as novice ideas that do not reflect strong conceptions of the nature of biology and instructional practices involved in teaching and learning biology. National Research Council (2000) stated that for teachers with less years of teaching experience, their epistemological believes about science and ways of learning science are not stable and are easily buckled by students' demand for less class work. Thus, it is crucial to improve their self-regulated thinking (Boruchovitch & Ganda, 2013). Contextual learning such as environmental conditions around and the school itself affect their instructional methods. Some of the facilities needed for ecology lessons like sweep nets and quadrats are simple and can be innovatively prepared by the teachers and the students. School authorities should improve communication patterns with parents to make organization of field trips easy and to reduce time wastage in fee collection. Biology teachers can use strategies that ease learning of terminologies.

CONCLUSION

The findings of this study revealed that constructivist instructional approach pay positive influence on learners' achievement in biology. In the same vein, there was a significant gender difference between male and female students' achievement in biology when constructivist instruction is used. Furthermore, students in single sex girls schools achieved the highest gain in mean, followed by students in the category of mixed boys and girls with the least gain registered by the students in single sex boys schools and thus indicating that constructivist instructional methods leads to higher achievement in single sex girls schools. On the other hand, the findings of this study revealed that students had positive attitude towards the constructivist instructional methods and that girls were more positive towards the constructivist instructional method as compared to the boys. This study therefore concludes that the constructivist instructional method is effective in improving learner achievements in biology and should therefore be adopted in secondary schools in teaching biology.

Based on these findings, biology teachers should be encouraged to use constructivist method of instruction, since the method is more effective in learning biology compared to conventional. Since learner attitude is important and has implications on performance, biology teachers should be able to adopt the constructivist instructional approach of instruction as it eliminates some of the classroom practices that do not encourage students to develop positive attitude towards biology. Finally, school administrators should be encouraged to improve on management of academic programs by providing necessary facilities required for instructional purposes specifically variety of textbooks, apparatus and equipment for practical lessons to promote constructivist approach of learning.

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