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5E INSTRUCTIONAL MODEL: INSTRUCTIONAL APPROACH FOR ACADEMIC ACHIEVEMENT IN CELL BIOLOGY CONCEPTS AMONG STUDENTS IN VIHIGA COUNTY, KENYA

Alice Nabie

A PhD student in Science Education, Department of Science and Mathematics Education, School of Education, Masinde Muliro University of Science and Technology. Email: nabiealice@gmail.com

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ABSTRACT

Cell biology is the basic concept of biology that focuses on the Structure and functions of the Cell. It is therefore a pre requisite for understanding of Biology, a subject that is not only applicable in our daily lives but also key in the research and the production world. Despite the role of biology, failure rate in the subject remains high. The aim of this study was to determine the effect of 5E instructional model on academic achievement in cell biology concepts among students of biology in Vihiga County, Kenya. Effectiveness of the 5E model on improvement of various science outcome has been supported by research conducted in schools. Mixed method research design comprising of quasi-experimental design and focus-group interviews was used. A sample of 550 students and 12 teachers of biology was selected using multi-stage sampling procedure. Data was collected using two achievement tests and an interview schedule guide. The reliability of the research instruments was determined using Cronbach's alpha coefficients while validity was established through consultation with research experts and practicing teachers. Data was analyzed using the independent sample t-test, at $\alpha = 0.05$. The main finding was that the 5E instructional model greatly improved student's academic achievement in cell biology concepts and additionally, it increased student's interest in the subject. It was therefore concluded that the 5E instructional model improved students' academic achievement in cell biology concepts. The results of this study may provide a basis for improving instruction in biology as well as in other subjects to realize improved achievement by the learners.

Keywords: 5E Instructional Model, academic achievement, Secondary Education Curriculum

INTRODUCTION

Cell biology is the basic concept of Biology that revolves around the idea that the cell is the fundamental unit of life. The cell forms the basic functional and structural unit of all living organisms upon which all life forms is built (Soza and Lee, 2021). Understanding of cell biology concepts permits detailed understanding of living organisms which form the basis of learning Biology. Biology as a subject plays a vital role in production in various fields such as medicine, Agriculture, Biochemistry among others; providing solutions to food scarcity, health, hygiene management and conservation of natural resources. Quality academic achievement in biology among students is therefore critical for development.

Studies have revealed that several Concepts of biology are difficult for students to master. Concepts related to the cell have been rated as extremely difficult to master (Sallah, Ahmad, Setyaningish, 2021). Their report specifically identified cell division, cell Structure and organization, and the chemical composition in the cell as areas of difficulty in the study of the cell life. According to Mehmet (2014), Cell division is one of the most difficult topics in science education for both teaching and learning. An analysis of student's performance in Kenya Certificate of secondary education (KCSE) in the country Kenya and Vihiga county reveal difficulty in the subject as indicated in results obtained over a period of time.

Table 1 KCSE Performance in biology for previous Four years in Kenya

YEAR	2019	2020	2021	2022
Mean Mark (%)	25.69	25.52	28.51	28.68
Mean Grade	D	D	D	D

Source: KNEC annual KCSE Reports, (2019-2022)

From Table 1, students mean scores in biology at KCSE is low and continue to decline over the years. This indicates that most students do not attain quality grades to pursue biology related courses necessary to realize desired growth in the country. The KCSE performance in biology in Vihiga County is not any better as shown in the Table 2.

Table 2: KCSE performance in biology for the years under study in Vihiga County

Year	2019	2020	2021	2022
M/Score (Country)		2.926	2.923	2.984
M. Grade	D	D	D	D

Source: County Director of Education- vihiga, 2023

From Table 2, the mean of biology in the county has not only remained low, but continues to pose a negative deviation each year. Unless this is addressed, the country may not realize its vision 2030 on development.

Analysis of KCSE question papers for the period under study reveal that cell biology concepts are examined each year. Table 3 shows the weight of questions on cell biology concepts in the three papers of biology done at KCSE.

Table 3: Number and total score of cell biology questions in KCSE biology papers

YEAR	2019	2020	2021	2022
Number of questions on cell biology	5	4	5	5
Total marks	30	28	24	28

Source: KCSE biology past papers, (2019-2012)

According to Table 3, cell biology concepts contribute an average of 27.6 marks out of a possible 200 marks. This is significant because the understanding of the cell biology concept at the secondary school level is also crucial for comprehending one of the 21 areas that rely on cell biology conceptualization. It is therefore possible that student's poor comprehension of cell biology concepts is the cause of their poor performance in biology at KCSE.

A number of studies have been conducted on the possible cause of the difficulties in learning biology including cell biology. Benjamin and Emmanuel (2017) identified abstractness, misconceptions, inadequate instructional materials and attitude as key concepts responsible for difficulties in learning of biology concepts. Other research findings include; the efficacy of teachers' instruction (Wamukota & Masibo, 2017), school-related issues (Mushtaq & Khan, 2016), the nature of textbooks used (Meenudev, 2016), and the teaching approach employed (Owusu, Monney, Appiah, & Wilmot, 2010). According to Shan and Khan (2015), most commonly utilized teaching techniques have not been successful in improving the learning outcomes among science students. Therefore, the study of teacher pedagogy is crucial in order to improve performance in biology. Several pedagogical research indicate that active

learning enhances students' academic performance in the classroom. According to Tutal & Yazar (2023), utilization of active learning methods positively impacted academic achievement and the retention of knowledge.

5E instructional model ihas been confirmed to be a more effective approach than teacher-centered methods of instruction. 5E is a constructivism approach influenced by Vygotsky's constructivism. The effectiveness of the 5E model on improvement of science education has been supported by research conducted in schools. 5E develops understanding of scientific knowledge and increases students' motivation. (Bakri & Adnan, 2021; Bezen and Bayrak, 2020.) It provides for development of critical thinking skills, argumentation skills, and the ability to apply the knowledge in practice (Amalinya et al., 2023; Ha et al., 2023). Use of 5E model exposes students to activities that foster discovering concepts using pre requisite knowledge (Nkurikiyimana et al, 2022). It is proven to develop all levels of cognitive processes pertaining Bloom's taxonomy.

Whereas a number of studies have been carried out on the effect of 5E instructional model on various aspects of biology; studies on its effects on academic achievement in cell biology remain minimal.

METHODOLOGY

The study employed mixed method research design with quasi- experimental design as the main component supplemented by focus group interview. This was ideal since the researcher used intact classes in schools which were included in the research. Study population comprised of all third-year students of biology in secondary schools in Vihiga county. Stratified random sampling was used to select a sample size of 550 students based on school category. The sample was then divided into two groups; assigned as experimental/treatment and the control group. Both groups were subjected to pre-test to establish homogeneity of the groups. The two groups were then taught the concept of cell division in the topic reproduction. The experimental group was taught using 5E instruction model while the control group was taught using the conventional method of instruction. A post-test was then administered to the two groups and their scores recorded. The scores were then analysed to determine if there was a difference in acquisition of scientific skills between learners who were taught using 5E instructional model and those taught using conventional approach. Interview schedules were organized for sampled students from each group and their responses were also recorded. Independent group t-test was used to establish if there was a significant difference in the student's academic achievement between the treatment group and the control group. T- tests was used based on the assumptions that there is; normal distribution of data, homogeneity of variance and independence of samples.

RESULTS AND DISCUSSION

The objective of this study was to determine the effect of using the 5E instructional model approach and the conventional teaching approach on students' academic achievement in cell biology concepts in Vihiga county, Kenya. Data was collected using three instruments; Cell biology achievement test I and II and focus group interview guide. Cell biology achievement test I was used as pre-test to establish students'

academic entry behavior based on cell biology concepts previously learnt. It was developed by the researcher based on KCSE past paper questions on the concepts of cell biology and in line with specific objectives outlined in the KICD syllabus.

It was a one-hour test that consisted of 12 items with a maximum score of 50 marks administered to all the learners in both groups after intervention. The items cut across all the six levels of Bloom's taxonomy. The test items consisted of short answer and structured questions. The test carried a minimum score of zero and a maximum score of fifty marks converted to 100% for the purpose of analysis. A score below 40% was considered poor; between 40% to 59% was considered fair while a score above 60% was deemed as good. Cell biology achievement test II was used as post test to determine if there was a difference in academic achievement in cell biology when 5E instructional approach was used as compared to when the conventional approach was used. It was similar in structure to the pretest. Six focus groups were established and subjected to the focus group interviews guide. Two randomly selected students from each sample school were interviewed, using a set of guiding queries established prior to the commencement of the study to provide the interviewers with guidance. The guiding queries were centred on the learners' experiences regarding the learning of cell biology concepts and the biology subject as a whole. The questions also addressed the student's perspective on the learning and teaching of biology, as well as their experience with the cell biology achievement test II. The quantitative findings were used to collaborate quantitative findings.

• Qualitative data analysis revealed as follows:

Table 4: Means and Standard Deviations of Pretest Data

Parameter of Learning	**Group**	**N**	**Mean**	**SD**
Academic Achievement	Exp	251	18.96	4.79
	Cont	254	18.59	4.58

Table 4 indicates that the experimental and control groups had mean scores that were comparatively similar in terms of academic achievement: (experimental) 18.96, S.D.=4.79; (control) 18.59, S.D.=4.58.

Table 5: Means and Standard Deviations of Posttest Data

Parameter of Learning	Group	N	Mean	SD
Academic Achievement	Exp	251	23..40	3.73
	Cont	254	18.63	3.80

Table 5 indicates that the experimental and control groups exhibited significant discrepancies in their academic performance scores, with the experimental group achieving a mean of 23.40 and a standard deviation of 3.73, and the control group achieving a mean of 18.63 and a standard deviation of 3.80.

• Inferential analysis revealed the following:

Table 6: T-test results on pretest scores

Parameter of Learning	Group	N	Mean	S	SD	T	P
Academic Achievement	Exp	251	18.96	0.96	4.79	14.84	0.519
	Cont	254	18.59	1.00	4.58		

Critical t at 0.05=1.96, df = 50

Table 6 indicates that in the pre-test scores, there was no significant difference in the academic achievement of learners with respect to cell biology concepts between the experimental and control groups; t (1.00) =14.84, p>0.05 at p<0.05

Table 7: T-test results on posttest scores

Parameter of Learning	Group	N	Mean	S	SD	T	P
Academic Achievement	Exp	251	23.40	1.03	3.73	5.37	0.000
	Cont	254	18.63	1.08	3.80		

Critical t at 0.05=1.96, df = 50

Based on results from table 7, there was a significant difference in academic achievement between the treatment and control group; t (1.08) = 5.37, p< 0.05; p value is less than the stipulated alpha;

The results indicated that the 5E instructional model approach had a substantial positive impact on the academic achievement of students in the cell biology. The experimental group, which was instructed using the 5E instructional model, achieved substantially higher scores on the achievement test than the control group, which was instructed using the conventional method. This was quite different from findings on the pre-test score analysis, which indicated that the two groups were statistically equivalent in terms of their academic achievement. These findings are in line with earlier finding by Senan (2013) asserts that the technology-enhanced 5E learning paradigm is a highly successful tool for students and teachers to develop 21st century abilities and teach specific concepts.

Focus group interviews were conducted to collaborate the findings from quantitative data. sampled student response from the experimental group interviewed expresses high levels of confidence to excel in the test. The students also had this to say;

ETQIS 1 *"I understood the topicof cell division much better than topics earlier taugh on the cellt. All students even those who never talk in class participated. Am sure I will score all the test items well because the questions were set directly from what we. Learned."*

ETQIS 2 *"our teacher taught us reproduction well and we all enjoyed the lessons. He gave us time to work together in groups and that enabled us understand the content well. Most learners were active and happy. Am sure I will score highly in the test. The questions were ok. I hope our teacher will continue teaching us in the same was."*

ETQIS 3 "*Reproduction lessons were enjoyable. We were all engaged and interacted with one another well as we learned. The teacher was mainly guiding us and we took the active role through discussions. We were able to relate all aspects in the lessons with real life experiences. The method the teacher used made everything to be realistic unlike when we keep on listening as the teacher teaches. I understood and I know that I have passed the test. Our teacher should continue using this method to enable all students to participate."*

The interview responses and score of sampled students from the experimental group clearly indicated that the 5E instructional model is an active, learner centered method that allowed learners to be active recipients of knowledge. In contrast, the following responses were given by learners in the control group.

CTQIS 1 *"Reproduction is the topic I was eager to learn though it became complicated with the cell division parts. There was a lot of confusion between types and stages. The teacher was very fast in teaching tough he gave us all the notes. I did not understand the difference well. The questions in the test were also confusing though I will not fail all of them. "*

CTQIS 2 *"The topic of reproduction was complicated by the cell division part. It was*

	confusing especially when it came to the stages of mitosis and meiosis. The teacher was also confused! The test was normal; however, biology exams are unpredictable. Sometimes marking is so strict."
CTQIS 3	*"Reproduction lessons were boring especially the parts of cell division. The teacher was very fast and most of the students were sleeping. The exam was a bit challenging with most questions concentrated on cell division. We were also not given enough time to prepare for the exam because some questions required cramming. Some questions were difficult."*

The responses from the control group students clearly indicated that the conventional approach is teacher centered with most students being passive recipients of knowledge. The approach left students with little confidence on test performance.

CONCLUSION

The main finding was that there was a statistically significant difference in student's academic achievement in cell biology when taught using the 5E instructional approach as compared to when taught using the conventional approach. The conclusion drawn was therefore that: the 5E instructional model approach of learning results in increased students' achievement in cell biology concepts among secondary school biology students as compared to the conventional teaching and learning approaches. it is more effective in teaching of cell biology concepts than the conventional approach. It enables students to attain higher scores in achievement tests,

RECOMMENDATION

Biology teachers need to employ innovative active teaching approaches, such as the 5E instructional model, which has been acclaimed for its positive impact on students' learning outcomes.

Teacher educator institutions need to adopt the use of 5E model and infuse it in the teacher education curriculum as a learning strategy under active learning.

Policy makers should embrace and facilitate adoption of 5E instructional model approach for quality learning.

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