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EFFECTS OF INQUIRY-BASED TEACHING ON STUDENTS' ACADEMIC ACHIEVEMENT IN BIOLOGY IN LOWER SECONDARY SCHOOLS IN ILALA –DAR ES SALAAM – TANZANIA

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Abstract

The purpose of this study was to examine the effect of inquiry-based teaching on secondary students' academic achievement in Biology. A total of 94 Form Three students from two different secondary schools in the Ilala district in Dar es Salaam – Tanzania were involved. A pre-test and post-test quasi-experiment research design was adopted for the study where students in one school were involved in inquiry-based teaching and those from the other school were conventionally instructed. To determine the effect of inquiry-based teaching, an achievement test in coordination in plants was administered as a pre-test and post-test to both groups. The test generated quantitative data that was analysed through descriptive statistics and inferential statistics where independent samples T-test was used. Findings indicated that students taught through inquiry-based teaching performed better than those taught through conventional methods. Implications for practice are discussed.

Keywords: Biology, Coordination in plants, Secondary education, Inquiry-based teaching.

Introduction

Biology is the natural science subject and amongst the compulsory subjects taught at the ordinary level in the secondary school curriculum in Tanzania. The subject is essential for many fields of learning contributing to the national economy such as medicine, agriculture,

biotechnology, and nursing (Ghumdia & Adams, 2017). Learning Biology equips learners with knowledge and skills that help them to face challenges in society especially those related to common diseases, pollution, and genetics. Furthermore, Biology subject leads to self-understanding and to how the body works (Kareem, 2018), hence deserves due consideration in school curricula as well as an emphasis on the teaching-learning continuum. It is, therefore, important that schools utilize effective methods to teach this subject so that students achieve the planned objectives.

However, despite the importance of Biology as a subject, and being at the core of the ordinary secondary education curriculum in Tanzania, the performance in Biology subject has remained persistently poor for years. Statistics show that only 30.5%, 37.1%, 48.1% and 53.7% students for 2012, 2013, 2014 and 2015 years respectively passed national examination in Biology (The United Republic of Tanzania, 2016). As a consequence, few students are selected to pursue Biology in advanced secondary education which contributes to the meagre pool of biologists in Tanzania. Hence, it was important to investigate the underlying factors to this poor performance in Biology in secondary education in Tanzania.

Students' poor performance has partly been ascribed to poor teaching methods adopted by teachers (Jepketer, 2017; Jolif, 2018; Nghambi, 2014). For instance, in the delivery of the curriculum content in secondary schools, studies have revealed that secondary teachers including Biology teachers mostly rely on the conventional methods that are mainly lectures, and sometimes few demonstrations to convey ideas and facts in the teaching and learning process (Blyth, 2010; King'arru, 2014). In these methods, it was observed that teachers dominated the class during the instruction process by transferring the knowledge with little or without inputs from the students. Students are passively involved, implying they just listen and receive information from their instructors. Indeed, teacher-centred methods limit students' participation, deep understanding of the concept, and creativity, hence seen to be poor in influencing students' achievement as compared to other alternative teaching strategies like Collaborative Learning Strategies, Instructional Technology Strategies, and Inquiry strategies (Chowdhury, 2016). Therefore to improve performance in Biology it is important to transform the teaching approaches. One way to do this is, as

is the focus of this paper, is to use inquiry strategies in the teaching and learning process.

Inquiry-Based Teaching

Inquiry-based teaching (IBT) can be defined as a pedagogy in which the teacher delivers curricula content via inquiry-based activities and students develop an understanding of the content by participating in actual scientific inquiry (Deboer, 2006). Also, Kinyota (2020) defined inquiry-based science teaching as the teaching process that comprises the methods followed by scientists when doing their studies. According to Blyth (2010), inquiry-based learning is an approach in which students learn by discovery; hence facilitates a deep understanding of the biology concepts and enables students to engage actively in the learning process. Furthermore, Inquiry was defined as the strategy of teaching in which learners seek information or knowledge of certain phenomena with minimal guidance from their teacher (Ghumdia & Adams, 2017). From these perspectives, it can be said that inquiry-based teaching is the way of teaching where students are actively engaged in the process of getting or searching certain planned knowledge or information through various ways used by scientists or inquiry-based activities. These ways include asking questions, formulating a hypothesis, making observations, collecting data, recording, and interpreting, and communicating the results (Şimşek & Kabapinar, 2010; Kinyota, 2020).

In the inquiry-based method, teachers are guiders and not any more providers. Students construct knowledge rather than being receivers. The inquiry-based method allows students to interact with their surroundings and make them able to see the abstract phenomenon in a real sense. So, it facilitates a deep understanding of the scientific content rather than rote learning or cramming. This also makes the learned information to be retained longer in memory hence improving performance (Issaka, 2020). Moreover, the method helps the preparation of future scientists because students normally experienced the usual but diverse ways scientists do to explore natural phenomena (Deboer, 2006). Furthermore, inquiry-based teaching develops among students 21st-century skills like collaboration, communication, and presentation skills (Wabuke et al., 2017). Several researchers have indicated that inquiry-based teaching has greater positive effects on students' academic achievement (Annan, et al., 2019; Njoroge, et al., 2014; Opara, 2011).

The present study adopted the 5E instructional model in its implementation of Inquiry-Based Teaching in the experimental group. As it has been explained by Bybee (2006) the model is comprised of five consecutive key elements. First, engagement: in this phase the teacher seeks to know the prior knowledge of the content from students. Students are engaged via discussion and in different activities that enhance curiosity in the concepts, skills, and behaviour to be learned. Exploration is the second phase in which students are exposed whether in field, experiments, simulations, or prepared documents. In this stage, it is where students develop knowledge and other planned objectives on their own instead of receiving them directly from the teacher. The role of the teacher in this stage is to scaffold students on the learning process (Issaka, 2020). The third phase is explanation where students make a presentation of what they are supposed to do in groups or as individuals based on the evidence from experiences. Also, it is where the teacher introduces new vocabulary missed in students' presentations and proper definition of concepts or behaviour. The fourth phase is elaboration whereby teachers posed challenges in new situations and students apply knowledge to the related concepts. This makes students extend their conceptual understanding as well as skills. The last phase is an evaluation where the teacher and students assess the achievement of the pre-determined objectives either through oral or written tests. These phases were used in the present study to guide inquiry-based instruction in biology especially in the topic of coordination in plants.

Purpose and research questions of the study

The study investigated the effect of inquiry-based teaching on the secondary students' academic achievement of biology. The study addressed the following research question:

- Is there a significant difference in biology performance between students taught through IBT and those taught through conventional teaching methods?
- Is there a significant difference in biology performance by gender for students taught using IBT?

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Methodology

Research approach and design

The study adopted a quantitative research approach where the pre-test and post-test quasi-experiment research design was used. Two groups: experimental and control were taken from intact classes from two different secondary schools. This is because, secondary schools classes exist as intact groups and school authorities do not usually permit classes to be dismantled and reformed for research purposes (Njoroge, et al.; 2014). Hence, there was no randomization of participants to the study. The schools were apart from each other and this control for the interaction among students across the treatment groups. Also, two different teachers taught the classes. The researcher made sure that the teacher who taught the experimental group was familiar with the 5Es model as stages for inquiry-based teaching.

Participants

Participants in the study were 94 form three students from two government secondary schools in Ilala district, Dar es Salaam region – Tanzania. The choice of form three students warranted that students involved in the study were acquainted with the subject – having studied Biology for more than two years as they were now in their third year of secondary education. Also, they were in a position to fully engage in the intervention activities since they were not preparing for any external examination – a factor that in many cases becomes a hindrance for involving students in treatments for research. Hence, the class level was selected purposively where one class was selected from each school. The intact classes were randomly assigned to experimental and control groups. The experimental group was exposed to the inquiry-based teaching method whereas the control group was exposed to the conventional teaching methods. The study received ethical clearance from the University of Rwanda and research permits from the Ministry of Regional and Local Government Authorities including the Ilala District Council in Tanzania. Also, before students participated in the study, teachers signed consent forms as guardians for the students.

Instrument

The data in the present study were collected through a Biology achievement test. Since students learned the topic of coordination in

plants during the intervention activities, only questions from this topic were used for the test. The questions were carefully adapted from previous national examination question papers of Biology between 2003 and 2019. Items were selected based on their suitability in assessing students' understanding of concepts of coordination in plants. The test was used for both pre-test and post-test. The test comprised ten (10) items including three multiple-choice items, four matching items, and three open-ended questions. The Biology achievement test was validated by two experts in Biology education and its reliability coefficient was 0.93 obtained by using test-retest on SPSS version 23.

Procedures

The present study comprised of two groups, namely the experimental group, and the control group. Before the intervention, a pre-test was administered to the participants in both groups. The pre-test was done before the intervention purposely to establish student's prior knowledge about the topic and the level of which they would start with as they get involved in the intervention activities. This would later act as a reference point in determining how they would improve their knowledge as a result of intervention activities. In addition, the pre-test enabled comparison between the two groups before they participated in the intervention activities. During the intervention, 42 students in the experimental group were instructed through an inquiry-based teaching method based on the 5E instructional model. Students were engaged through short activities to raise curiosity, explored, and presented their conceptual understanding from the experiment they were exposed to. The control group had 52 students who were instructed via conventional teaching method mainly lectures with the assistance of few drawings to explain the concepts from predetermining objectives. The treatment was done strictly on the selected topic from the form three secondary biology syllabus which is coordination in plants. At the end of the intervention, the post-test was conducted on the students to measure the achievement of the students in coordination in plants.

Data analysis

The data obtained were analysed based on two research questions using descriptive statics such as mean and standard deviation, the statistics that provided an understanding of how students scored on the test. To

address the research questions, a T-test was used to determine the differences between students' scores at 0.05 level of significance. In addition, to explain the magnitude of variation in students' scores that contributed to differences assessed using the T-test, Cohen's d was used as the effect size where 0.2 is small, 0.5 is medium, and 0.8 is large (Cohen 1988).

Results

Effects of IBT on students' achievement in Biology

With regard to research question one (1): Is there a significant difference in biology performance between students taught through IBT and those taught through conventional teaching methods?, the pre and post-test were given to both groups: control and experimental, and the mean score results illustrated in Table 1 and Table 2 as follows:

Table 1. Means pre and post-test results of control and experimental groups

	Treatment	N	Mean	Std. Deviation
Knowledge Test 1	Control	52	47.19	15.529
	Experimental	42	48.19	16.515
Knowledge Test 2	Control	52	49.31	14.823
	Experimental	42	56.21	16.725

In accordance with the data portrayed in Table 1, the pre means scores obtained from the control group which was taught using the conventional method and the experimental group that was taught through inquiry-based teaching were 47.19 and 48.19 respectively. This shows that the experimental group performed slightly higher than the control group. However, when the post-test was carried at the end of the intervention, a difference in mean scores was large. Students taught using the IBT method had a higher mean score (56.21) as compared to those in the control group (49.31). This indicates that the IBT method could affect students' achievement. To see whether there was a statistically significant difference between the means of control and experimental groups obtained in pre and post-test, an independent samples t-test was carried out and the results are presented in Table 2.

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Table 2. T-test analysis of pre and post-test results of control and experimental groups

	t-test for Equality of Means							Cohen's d
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper	
Knowledge Test 1	-.301	92	.764	-.998	3.314	-7.581	5.584	0.06
Knowledge Test 2	-2.121	92	.037	-6.907	3.257	-13.375	-.438	0.4

Results from Table 2 shows that, there was no significant differences between the pretest mean scores of the control group correspondingly to the size effect was found to be small **(***M* = 47.19 , *SD* = 15.53) and the experimental group (*M* = 48.19 , *SD* = 16.52) ***t*(**92) = -.301, *p* > 0.05, *Cohen's d* = 0.06. It may be concluded that both groups were equal in prior knowledge of the concepts of coordination in plants. However in post-test it was revealed that there was a statistically significant difference in Biology performance between the students taught using IBT but there was a small effect size (*M* = 56.21, *SD* = 16.73) and students in the control group (*M*= 49.31, *SD* = 14.82) *t* (92) = -2.121. *p* = 0.037 < 0.05, *Cohen's d* = 0.4. Hence, it can be inferred that IBT is likely to have contributed to the higher achievement in learning the coordination in plants topic as compared to conventional methods.

Effects of IBT in Biology performance by gender

In line with the research question 2: Is there a significant difference in Biology performance by gender for students taught using IBT? The following results were obtained as illustrated in Table 3-4.

Table 3. Means pre and post-test results of male and female students taught using IBT

	Gender	N	Mean	Std. Deviation
Knowledge Test 1	Male	22	47.32	15.298
	Female	20	49.15	18.112
Knowledge Test 2	Male	22	50.91	16.024
	Female	20	62.05	15.856

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The data presented in Table 3 communicate that the pre mean score results of the male students instructed through inquiry –teaching was 47.32 where that of females was 49.15. This indicates that female students had slightly higher scores than their counterpart male students. However, when the post-test was carried at the end of the intervention, a difference in mean scores was large. Female students had a higher mean score (62.05) as compared to male students (50.91). This indicates that the IBT method could affect female students' achievement. To see whether there were statistically significant differences between the means of male and female students obtained in pre and post-test, an independent samples t-test was carried out and the results are presented in Table 4.

Table 4. T-test analysis of mean pre and post-test results of male and female students taught using IBT

	t-test for Equality of Means							Cohen's d
						95% Confidence Interval of the Difference		
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper	
Knowledge Test 1	-.355	40	.724	-1.832	5.158	-12.256	8.592	0.1
Knowledge Test 2	-2.262	40	.029	-11.141	4.926	-21.097	-1.185	0.6

As shown in Table 4, the test shows that there were no significant differences between the pre mean scores of the male students. That why, no wonder the effect size was small (M = 47.32, SD =15.30) and the female students (M = 49.15, SD = 18.11) t(40) = -.355 p > 0.05, *Cohen's d* = 0.1. It may be concluded that both groups were equal in prior knowledge of the concepts of coordination in plants. However, in post-test it was revealed that there was a statistical significant difference in Biology performance between male students correspondingly to the effect size was found to be medium (M = 50.91 , SD =16.02) and female students (M = 62.05 , SD = 15.86) t(40) = -2.262, p = .029 < 0.05 , *Cohen's d* = 0.6. Hence, it may be concluded that IBT contributed to the higher achievement in learning the coordination in plants topic on female students as compared to male students.

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Discussions

The study findings show that the use of inquiry-based teaching had a significant effect on the students' achievement in Biology. This concurs with Adejo (2015) who indicated that the inquiry approach was effective on students' understanding of scientific knowledge. Also, the results agree with Opara (2011) who revealed that students exposed to the inquiry approach scored higher on the test composed in the selected units of Biology than students exposed to the traditional method. Moreover, the results are in line with Annan et al. (2019) who found that students taught using the Inquiry-based teaching method did better on the Biology test than those taught using the lecture method. This implies that with the use of the inquiry-based teaching method students may understand the Biological concepts better since the conceptual understanding is developed based on the evidence from the experiences and not transmitted directly from the teacher.

On the other hand, the study revealed that female students performed better than males in the post-test. The pretest showed that female students performed slightly higher than their counterpart male students. This may suggest that in this class, female students were more interested in Biology and showed to be good at it than male students. Probably, it is for this reason that they were even more interested in IB activities that made them do even better in the post-test than male students.

These findings are inconsistent with Opara (2011) who indicated that males scored high than females when taught some selected units of Biology using the inquiry approach. He explained that this was probably because pictures in books and models for teaching were gender biases favoring boys than girls. However, the reason stipulated is not associated with the examined method. Also, the study results were contrary to those by Adejo (2015) who found that the post-test mean scores of males and females in the conceptual understanding of the selected topics of chemistry subject were not statistically significant with the use of inquiry-based teaching method. So, Adejo confirmed that the IBT had no impact on gender. The contradicting findings suggest that there is a need for more research on the effects of IBT on students' performance by gender. Future research may therefore examine how

girls and boys get engaged with IB learning activities and how this may affect their interests and performance.

Conclusion and recommendations of the study

The use of the inquiry-based teaching method via the 5Es was seen to be an effective approach for teaching biology and other science subjects. This method improved students' achievement as seen in the findings of the study and other earlier similar findings. It helps students to internalize the understanding of the concepts since students pass through series of activities to come up with knowledge. From the findings, it is worth recommending that biology teachers should use more learner centered teaching methods such as IBT to actively involve their students in the learning process. By doing so, teachers will be facilitating students to construct knowledge rather than being mere receivers of information.

Disclosure statement

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