



Innovation of Instructional Materials in Learning Biology Lessons in the Digital Era: Are the Teachers Shying Away from Digital Resources?

Ashura Halifa Hassani & Prosper Gabrieli
University of Dodoma-Tanzania

ORCID: <https://orcid.org/0000-0009-4852-5563>

ORCID: <https://orcid.org/0000-0003-4913-0781>

Email: ashurahalifa01@gmail.com/pgabrielimo@gmail.com

Abstract: Innovation of instructional materials during the learning exertion is widely recognized to enable students to be more competent in different subject matter. This paper investigates teachers' innovativeness in using instructional materials in teaching and learning of Biology subject. A total of 42 Biology teachers responded to the questionnaires during data collection. Frequencies, means and percentages on teachers' innovativeness of the instructional materials in teaching and learning of Biology subject from observation and questionnaires data were calculated and presented in table and graphs. Only funnels were innovated by all schools followed by models, and Bunsen burners, which were innovated by at least half of the schools involved in the study. Innovation of digital materials such as projectors, computers, tablets, radios and educational slides was not encouraging. Counting merely on analogy materials such as chalks and blackboard over digital materials will produce the students who are not creative, incompetent and students who are unable to solve different problems that occurred in their daily life especially in this digital era. We recommend investment on teachers' in-service training programs in enhancing innovation of wide range of the instructional materials including the digital materials.

Keywords: Innovation, Instructional materials, Biology lessons, Digital resources.

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1. Introduction

Biology is a scientific study of the life of all living organisms. The study includes the structure of their bodies, how they function, growth, evolution, distribution and how it stays healthy (Mardonov, 2019; Felicia, 2016). It is a highly relevant scientific study to the existence of all forms of human and non-human species on earth (Mouhamad, 2018). Biology education helps people to develop science process skills and scientific attitudes that pave a way to different forms of organic life and their interrelated relations with environment and other sciences (Mardonov, 2019). These are key in maintaining humankind and other living creatures' health in this earth's biosphere.

Biology education has been a vibrant weapon for the survival of human species. Educating people in Biology as in other science subjects has been acknowledged as a means of promoting economic development, eliminating poverty and introducing social welfare (Mardonov, 2019; Felicia, 2016). Biology education is needed for better and effective food production and food safety, quality medication, welfare provision and portable water supply (Omiko, 2005). The biology knowledge contributes to the discovery of new facts which can contribute to solving numerous everyday problems (Miljanovic, 2003). Evidently, effective learning of Biology would eventually nurture human species and lead them to a wise, careful, and human planning to have a sustainable life.

According to Nwankwo, Ugwu, and Ngwu (2019) effective teaching and learning of Biology subjects can be enhanced through the innovation of instructional materials that help students engage in learning. Innovation has emerged as a symbol of contemporary society, a solution to numerous issues (Benoit, 2008). The innovative learning materials enable students to be more competent in different subject matter. They should be flexible to meet the learner's needs, develop their creativity and problem-solving skills, and improve students' achievement from a virtuously academic standpoint (Serdyukov, 2017; Suarman et al, 2018). Therefore, innovative instructional materials should be designed in a way that help to make students creative, able to solve different problems, and improve their academic performance in Biology subject.

Different experts elaborated the meaning of innovation based on different perspectives. Thomson (2023) defined innovation as changing something established by introducing a new one. Innovation can occur as new instructional tools that produce critical changes in teaching and learning, leading to better student learning (Serdyukov, 2017). The new instructional tools can be improvised materials to facilitate teaching and learning.

Furthermore, scholars classified innovation into different classes. Innovation can be classified as tangible. For example, technology tools (digital) or Information and Communication Technology (ICT) facilities such as projectors, video, tablets, computers, tablets, and iPads, and other improvised instructional materials against conventional instructional materials such as using a dead electric bulb with water as a hand lens, a drinking straw as a delivery tube, and a transparent rubber container as an aquarium (Ahmed, 2008; Apulu et al, 2011; Ibrahim et al 2021; Serdyukov, 2017). ICT facilities enhance creativity and communication skills among learners and provide different environments that make students enjoy the lesson (Sarmah & Das, 2020). Also, innovation can be classified as intangible, for example, methods, strategies, and techniques (Serdyukov, 2017). Carless, (2013) cemented these classes by given more examples such as task-based teaching, changes to teaching materials, technological development including computer assisted learning, and alternative assessment methods like portfolio. Therefore, different teaching methods, strategies, and teaching and learning techniques are innovations in an intangible form.

Brewer and Tierney (2012) assert that innovation in instructional materials can be enforced because of demand. Therefore, the scarcity of instructional materials calls for innovation. Evidence shows that some of the instructional materials for teaching and learning Biology are not available at all in most secondary schools worldwide and some are insufficient. The study by Obomanu (2011) revealed that, the Biology resources for the facilitation of learning process are lacking and some are insufficient. To cement this evidence, the study by

(Njuguna (2018) revealed that the accessibility of teaching and learning materials are below the mean. Most schools are characterized by lack of instructional materials due to high enrollment. The study of Isma'il and Lukman (2019) also revealed that, the instructional materials that relate to multimedia are absent in most of the secondary schools. The study conducted by (Ibrahim et al, 2021) revealed that a lack of adequate supply of instructional materials, using teacher-centred instructional strategies, and using abstract standardized materials lead to poor academic achievement in Biology subject.

This evidence implies that with limited instructional resources, teachers may innovate the instructional materials to meet the demand as what has been suggested in Tanzania ordinary level Biology syllabus and the recommendations from different researchers. It was stated in Tanzania ordinary level Biology syllabus that, Biology teachers can innovate other teaching and learning resources more than that stipulated in the syllabus when the needed arise (URT, 2010). Also, it was recommended that, teachers should be trained on how to be innovative in using different instructional materials when teaching (Njuguna, 2018). However, the studies concerning teachers' innovativeness in using the instructional materials in teaching and learning of Biology subject are uncertain. Therefore, the study to investigate teachers' innovativeness in using the instructional materials in teaching and learning of Biology is crucial at this venture.

1.1 Statement of the problem

Availability and efficient use of educational resources in the teaching and learning process improve learning achievement. Various programs guarantee the availability and utilization of instructional materials for teaching and learning biology disciplines. The programs include the 1975 establishment of the Tanzania Institute of Education (TIE), the training provided by the Ministry of Education, Science, and Technology (MoEST) and the Japan International Cooperation Agency (JICA), School Quality Assurers, and the language-supportive biology textbooks written by Gabrieli, Sane, and Alphonse (2018).

Despite these initiatives, academic performance in Biology, specifically on nutrition, classification, and transporting materials in living, is not encouraging. Most students score less than 30% of the possible points for a question on a topic, of which the majority score zero. This situation has been connected with scarcity of instructional materials as suggested in the study of Effiong et al (2015) study of Pareek, (2019), and study conducted by Etobro & Fabinu, (2017). Despite the scarcity of instructional materials in teaching Biology subjects, data concerning the innovativeness of instructional materials in teaching and learning Biology

are uncertain. Therefore, this research is intended to investigate teachers' innovativeness in using the instructional materials in teaching and learning of Biology subject.

1.2 Research Questions

This study guided by one research question. What is the teachers' innovativeness in using instructional materials in teaching and learning of the biology subject?

2. Literature Review

2.1 Theoretical Framework

The Connectivism Learning Theory, which George Siemens promoted in 2005, served as the foundation for this investigation. It is predicated on the idea that learning takes place in ambiguous settings with shifting fundamental elements that are under the person's control (Siemens, 2005). He put up eight connectivist tenets. One idea is that non-human devices might be capable of learning (Siemens, 2005). According to this hypothesis, learning can take place on different devices, including information and communication technology (ICT) devices like computers, tablets, laptops, cellphones, and the internet. So, the learners must know where the information is, analyze it, connect data and information sources, and make meaning. Also, he maintained that the tools we employ define and form our thinking because technology is renovating our brains. He concluded that using new tools changes how students learn.

This theory relates to this study as it guides the study to locate information-rich instructional materials for teaching and learning Biology subjects. The strength of this theory is that it provides a wide choice of different instructional materials, including digital devices. Therefore, the study assessed teachers' innovativeness of instructional materials for teaching and learning Biology subjects.

2.2 Empirical Study

Innovation has emerged as a symbol of contemporary society, a solution to numerous issues (Benoit, 2008). Effective use of instructional materials, some of which are introduced through innovation, is necessary for meaningful learning in biology classes. To achieve the specified curricular goals and enhance academic achievement, teachers and students make use of the instructional resources provided in their schools by various education stakeholders. Numerous research has shown that poor academic performance in science subjects, particularly biology, is caused by a lack of teaching materials in the educational setting (Okori et al, 2017). Many nations, including Tanzania, suffer from

low academic achievement in science courses like biology. Refer to Table 1 in Appendix 1.

According to Etobro et al (2017) instructional methods, student attitudes, and insufficient learning materials all cause students to struggle with certain ideas. According to Aina (2013) there are no computers, audio cassettes, projectors, models, radios, or videos available to teachers for use in the teaching and learning process. By projecting various concepts, the teaching materials assist pupils comprehend abstract concepts. These results demand innovative approaches to guarantee that all of the teaching resources included in the biology curriculum are easily accessible in classrooms and used efficiently to improve student performance. According to Tanzania's ordinary level biology syllabus, biology instructors can create new teaching resources to satisfy student need (URT, 2020). According to Okori et al (2017) teachers are expected to innovate when educational resources like computers, televisions, charts, audio, and visual materials are unavailable or insufficient. As a result, biology teachers can create innovative teaching materials by utilizing locally accessible resources (improvise) or by introducing or utilizing new teaching instruments during the teaching and learning process.

Teachers have relatively little awareness of innovation in instructional materials, according to scholars of several research on the use of locally available materials (Odu, 2013). According to (Ndirangu et al (2003) scientific instructors may be reluctant or unable of creating innovative teaching materials since they must be paid for the additional time required to inspire them to do so. According to Stephen (2015) study, teachers face a number of challenges when it comes to innovation, such as a lack of skills, improvisational techniques, big class sizes, time limits, and a lack of exposure to innovation.

3. Methodology

The section comprised a research approach, research design, sample size, sampling procedures, data collection methods, data management, data analysis method, and validity and reliability of the study.

3.1 Research Approach

The quantitative research approach was thought important to attain the established research objectives on assessing teachers' innovativeness in using instructional materials in teaching and learning of Biology subject. This approach will help to get specific information on innovation of instructional materials in teaching and learning of Biology subject.

3.2 Research Design

A descriptive survey design, which enables the combination of questionnaire data and data from

observation employed. Teachers were required to tick the correct responses on a questionnaire guide. Each respondent's responses were recorded and kept in the cloud using a Kobo Toolbox for further use. The observation rubric that was stored on the tablet served as a guide for the data collector, who tick the innovated and non-innovated instructional material. The results were saved and stored in the Kobo Toolbox App cloud for subsequent use. The data gathered through questionnaires and school observation rubrics was retrieved from the Kobo Toolbox app cloud and analysed with Microsoft Excel. To determine the teachers' innovativeness of the instructional materials, the results were merged during data analysis and discussed collectively.

3.3 Sample, Sample Size and Sampling Procedures

The study involved 42 Biology teachers from eleven secondary schools in the Dar es Salaam region in Tanzania. All teachers in the selected schools were purposively sampled to be involved in this study. Biology teachers, as in the case of science teachers in Tanzania, are scarce and relatively low in the country. For this reason, all teachers found in any participating schools were considered in this study.

3.4 Data Collection Methods and Instruments

This section involved the methods and instruments used to collect the field's qualitative and quantitative data. The data collection methods used in this study were questionnaires and observation. The study employed more than one data collection method because it was expected to provide valid and reliable data by triangulating them.

3.4.1 Questionnaire

A questionnaire was employed to gather data from Biology teachers about teachers' innovation of the instructional materials for teaching and learning of Biology subject. This method was employed because it allowed the data collector to gather data from a large sample. The weakness of the questionnaire method is that it gives incomplete entries because most respondents fill in the questionnaire form poorly and leave out many questions. This weakness was rectified by preparing a software App called Kobo Toolbox App, which managed the data and did not allow the respondent to answer the next question before answering the previous question.

Structured questionnaires were used to gather data on teachers' innovativeness of instructional materials for teaching and learning Biology subjects. It comprised six closed-end questions. The items were adopted and

modified from the work (Nwankwo et al., 2019). Teachers had to tick the most correct response against the questions. These instruments, managed in a Kobo Toolbox App and downloaded within the tablets, were administered to teachers. The responses are saved offline and submitted online to the cloud in a Kobo Toolbox for further processing.

3.4.2 Observation

The non-participant observation method was used in this study to discover teachers' innovativeness of instructional materials for teaching and learning of Biology subject. This method was employed in this study because it helped to capture reality by getting first-hand data through direct observation, which helped to triangulate the field data from teachers' and students' responses. The observation checklist was prepared in software, which was the Kobo Toolbox App. The tool is downloaded from this App and provided on a tablet.

The checklist comprised a list of standard instructional materials identified in the ordinary-level Biology syllabus of 2010 and other instructional materials adopted and modified from the study of Ahmed (2008) intended to get data on teachers' innovativeness of instructional materials for teaching and learning of Biology subject. These instructional materials were, visual materials which were wall pictures, projectors, wall charts, models, journals, Biological diagram and photographs; audio materials which is radio ; audio-visual materials which are television, video tape, educational slide, film, computers and tablets; realia materials such as, Biology laboratory, indicators, aquarium, and Biology laboratory instrument and apparatus such as test tube holders, beaker, droppers, petri dish, mortar and pestle, tripod stand, Bunsen burner, funnel, plant press, round bottom flask, measuring cylinder, sweep net, pooter, spatula, watch glasses, rat-hook, potometer, and clinostat; and printed instructional materials including magazine, practical manual, and Biology text book. The data collector had to put a tick to indicate the innovated instructional materials and the instructional materials not innovated.

3.5 Data Management

The qualitative and quantitative data from the field were collected and maintained using a software App called Kobo Toolbox, a field notebook, an audio recorder and photographs.

3.5.1 Kobo Toolbox App

The questionnaires and observation checklists were prepared in a software App, Kobo Toolbox, by collaborating with a statistician who managed the App. The researcher downloaded the App using the special username provided, and then the App became available

on the researcher's tablet for data collection. The data was collected and saved offline, then submitted to the App manager online, where the data arranged together in the App according to how they were prepared. The data set is downloaded and stored in a flash card, Google Drive, computer, and email for further processing.

3.5.2 Photographs

Different photographs were taken during the school observation. The photographs concerned teachers' innovativeness of instructional materials for teaching and learning Biology subject. Photographs of those innovated instructional materials were taken using the smartphone camera, stored in the smartphone gallery, and protected by the passcode. Also, the pictures were retrieved from the computer for further safety.

3.6 Data Analysis Method

The data set was retrieved from the Kobo Toolbox App and then analyzed through a descriptive analysis using Microsoft Excel. The quantitative data from schools' observations on teachers' innovativeness in using instructional materials in teaching and learning of Biology subjects were analyzed using the frequency of the schools that innovated the specific instructional materials from the standard list. Then, their frequencies are in the tables and bar charts. On the other hand, the quantitative data from teachers' structured questionnaire on teachers' innovativeness of instructional materials for teaching and learning of Biology subjects were analyzed using frequency and percentage and then the results in one table to reveal different findings.

3.7 Validity and Reliability

A pilot study and Cronbach's alpha to ensure validity and reliability.

3.7.1 Pilot study

The pilot study was conducted at Viwandani secondary school and Dodoma secondary school. The questionnaire prepared in software was provided to 11 Biology teachers to give their responses. The questionnaire for

Biology teachers was administered to Biology teachers to get their responses about the teachers' innovativeness in using instructional materials in teaching and learning of Biology subject. Then, the interpretation of the data obtained was shared with statisticians, and some items were changed, modified to sharpen the tool, and approved for data collection. All the ambiguous and repeated questions were removed. All these modifications were made to make the research tools provide the intended information regarding the study's research questions to ensure validity.

3.7.2 Cronbach's alpha

Along with the descriptive analysis, the reliability of the questionnaires was computed using Cronbach's alpha coefficient. The overall alpha value was $\alpha = 0.93$, suggesting that the tools used were highly reliable. The value for each item making up the questionnaires was above the minimum reliability ($\alpha \geq 0.70$), indicating that they all measured related constructs.

4. Discussion of Results

The intention was to know if teachers innovate instructional materials in teaching and learning Biology subjects in a scarce learning environment. The results on innovation were obtained through school observation and teachers' structured questionnaires. The two themes generated. These themes are innovations based on standard list of the instructional materials, and innovations based on teachers' responses.

4.1 Innovation based on Standard list of the Instructional Materials

The findings in Figure 1 show the results gathered through school observation about the innovation of instructional materials specified in this study's standard list of instructional materials. The result was obtained by counting the number of schools that innovated the specific instructional material for teaching and learning Biology subjects on the list.

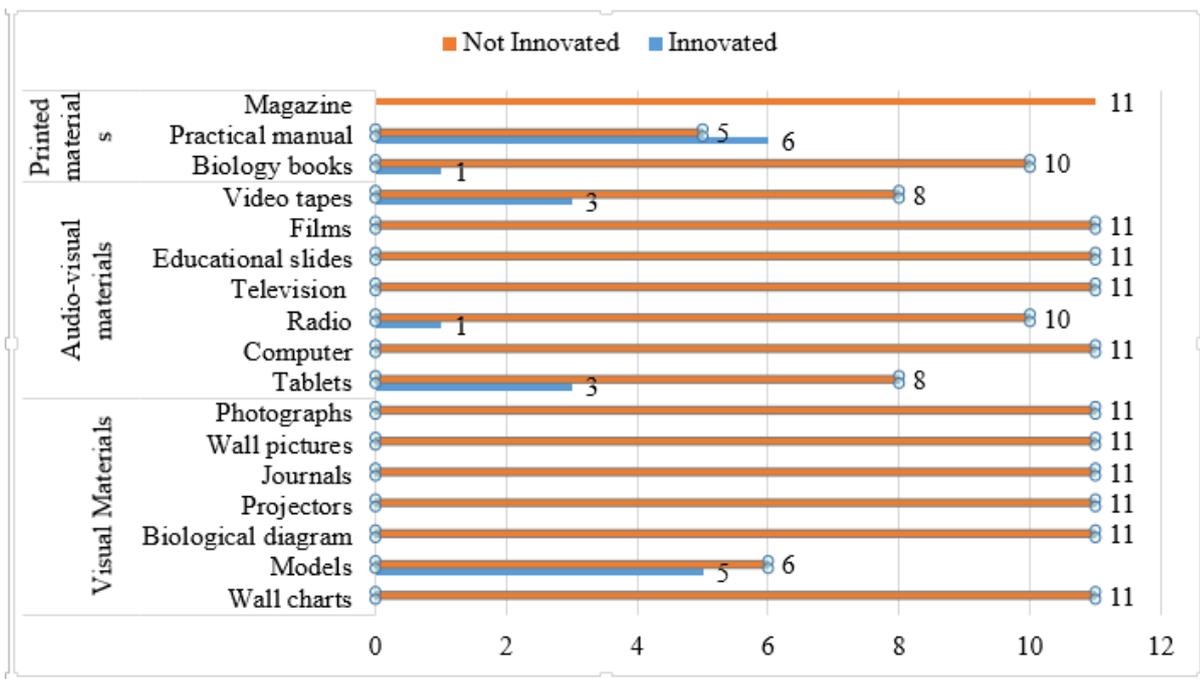


Figure.1
Source: Field Data (2023).

The results in Figure 1 show that most of the biology teachers in most of the schools do not show the innovativeness in using the instructional materials as only practical manual was innovated by more than the half of the schools involved. Most of the instructional materials were not innovated by all schools except for models, video tapes, radio, biology textbooks, and

tablets. The practical guides were innovated as an alternative to practical manuals. In some schools, they innovated different models, such as the model of neurons, the alimentary canal, the heart, and the human reproductive system. These results are revealed also in Figure 2 regarding the innovation of the realia materials.

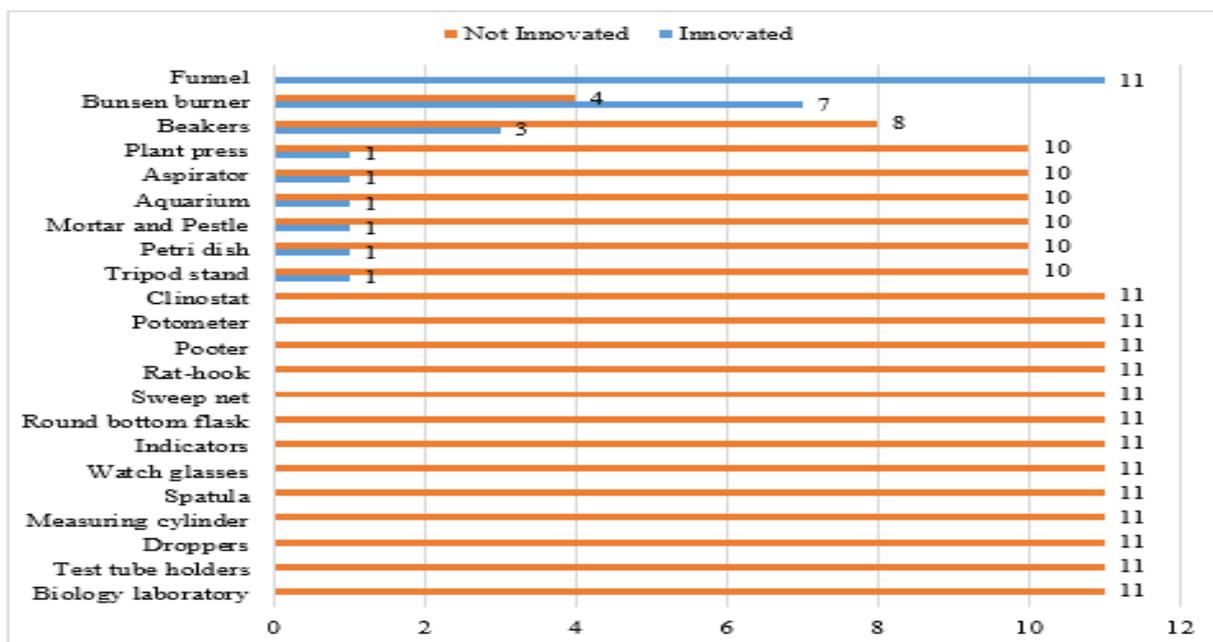


Figure 2
Source: Field Data (2023).

The findings show that only Bunsen burner was innovated by more than half of the schools that participated. Other instructional materials innovated by less than half of the schools include beakers, plant press, aquariums, mortar and pestle, Petri dishes, and tripod stands. All the rest of the instructional materials were not innovated. Other schools use kerosene burners, spirit burners, and gas cookers as alternatives to Bunsen burners. Also, the mortar and pestle were innovated

4.2 Innovation Based on Teachers' Responses

The findings in Table 2 were obtained through teachers' structured questionnaires on the innovation of instructional materials. Biology teachers had to mark the correct response. All teachers involved in the study responded to all questions. The frequency of teachers' responses was counted, and their percentages were calculated.

Table 2: Innovation based on teachers' responses

Instructional materials mostly used to present Biology lesson	Count	Percentage	
Chalk and blackboard	35	83.30%	
Chalkboard and power point	6	14.30%	
Power point	1	2.40%	
Grand Total	42	100.00%	
How often the above instructional materials used to present Biology lesson	Count	Percentage	
Every time	40	95.20%	
Sometimes	2	4.80%	
Rarely	0	0.00%	
Grand Total	42	100.00%	
Have ability to utilize power point in teaching and learning of Biology subject	Count	Percentage	
High ability	15	35.70%	
Little ability	24	57.10%	
No ability	3	7.10%	
Grand Total	42	100.00%	
Instructional materials used to facilitate learning process of Biology subject in a limited instructional material	Count	% of Response	% of Cases (N=42)
Localized available materials	29	46.80%	69.00%
Diagram drawn in manila sheet	33	53.20%	78.60%
I use no other materials, i teach them without instructional materials	0	0.00%	0.00%
Total	62	100.00%	147.60%
Engaged students in developing instructional materials for teaching and learning of Biology subject	Count	Percentage	
Every time	6	14.30%	
Sometimes	30	71.40%	
Rarely	6	14.30%	
Grand Total	42	100.00%	

Have expertise in developing instructional materials in a limited instructional material for teaching and learning of Biology	Count	Percentage	
High expertise	22	52.40%	
Little expertise	20	47.60%	
Grand Total	42	100.00%	

Source: Field Data (2023).

The findings revealed that many teachers use chalk and a blackboard whenever teaching their students. Only one teacher out of all teachers involved in the study utilizes PowerPoint whenever teaching. The findings also show that most teachers have little ability to innovate with power points in the teaching process.

In contrast, a few teachers have no ability at all to utilize power points in the teaching and learning process of Biology subjects.

The findings also show that most teachers use more diagrams drawn on manila sheets to facilitate the learning process in limited instructional materials than innovating the localised materials. The results show that many Biology teachers who participated in the research have high expertise in innovating instructional materials in limited instructional materials. The rest of the teachers have little expertise with no expertise in innovating the instructional materials for teaching and learning the biology subject.

Generally, the findings revealed that most schools do not innovate most of the instructional materials used for teaching and learning Biology subjects regardless of their scarcity, except for a few instructional materials such as practical manuals, models, and Bunsen burners, which were innovated by at least half of the schools involved in the study. Only funnels were innovated by all schools. This correlate with the study of Ndirangu et al (2003) which revealed that science teachers may be reluctant or unable of creating innovative teaching materials since they must be paid for the additional time required to inspire them to do so. But again, the results show that most teachers use diagrams drawn on manila sheets to facilitate the learning process in limited instructional materials rather than innovating with locally available materials. Innovation has a great contribution to the effective teaching and learning of Biology subjects (Nwankwo et al., 2019) assert that effective teaching and learning of Biology subjects can be enhanced through the innovation of instructional materials that help students engage in learning.

The innovation of Information and Communication Technology (digital) instructional materials in the teaching and learning process is not encouraging since many teachers use chalk and a blackboard whenever teaching their students. Only one teacher out of all teachers' participants uses PowerPoint which involves the use of projector, computer, and educational slides whenever teaching. This is consistent with research by

Salehi et al (2012), which found that although teachers have a great desire to use ICT in the classroom, they are hampered by inadequate technical support at school, shortage of class time and limited internet and ICT access. Also, this can be associated with a lack of the ability to utilize the ICT facilities. This is supported by the findings from the structured questionnaire, which revealed that most teachers cannot innovate with power points in the teaching process. In contrast, a few teachers have no ability at all to utilize power points in the teaching and learning process of Biology subject. This correlate with the study of Stephen (2015) which revealed that teachers do not innovate due to some barriers including lack of exposure to improvisation.

Despite the fact that pooter and sweep net are simple to innovate using local materials, the results show no schools innovated them. However, the findings of the structured questionnaire revealed that most teachers who participated in the research have high expertise in innovating instructional materials in limited instructional materials. This implies that the students are less or not at all engaged in collecting specimens using these instructional materials. Also, it implies that students are not interacting with these instructional materials in learning process.

5. Conclusion and Recommendations

5.1 Conclusion

The study publicized that most of the instructional materials required for teaching and learning during Biology lessons are not innovated regardless of their scarcity. Also, the study shows that teachers are shying away from digital resources by embracing analogy nstruactional materials. Without engaging in innovation of the instructional materials in teaching and learning of Biology subject, the education industry will produce the students who are not creative, incompetent and the students who are unable to solve different problems that occurred in their daily life especially in this digital era.

5.2. Recommendations

The suggestions proposed in this study based on the findings revealed. The section categorised into recommendations for policy action and recommendation for further studies.

5.2.1 Recommendations for Policy Action

The Ministry of Education, Science and Technology (MoEST) in Tanzania, through the Tanzania Institute of Education (TIE) and Po-RALG, should invest in rigorous and continuous professional development programs for Biology teachers to enhance innovation of different instructional materials during learning. These instructional materials should include using digital (ICT facilities) such as supportive devices like projectors and chrome casts, especially in this era of digital technology. This digital technology could help enhance learning and implement the ICT policy for basic education to transform Tanzania society from a knowledge-driven society to an information- and digital-driven society. As the Government, through TIE, is currently formulating and developing new curriculum guidelines and syllabi, it is high time for policymakers to consider the significance of instructional materials embedded with ICT for teachers and learners of Biology and other science subjects.

5.2.2 Recommendations for Further Studies

The study presented an intensive analysis of "Innovation of Instructional Materials in Learning Biology Lessons in the Digital Era: Are the Teachers Shying Away from the Digital Resources?" However, a lot is not addressed in this single study. Therefore, it is recommended to uncover:

The study revealed teachers expressing themselves as experts in designing instructional materials with limited resources and claimed to have attended in-service training opportunities. On the contrary, they do not innovate the scarcely available instructional materials, even the specifically available ones. The study recommends another study to investigate the reasons behind this gap.

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Appendix 1

Table 1: Poorly performed topics in CSEE

Year	Topic examined	Students scored 30% and above	Students scored below 30%
2015	Transport of materials in living things	08.40%	91.60%
2017	Reproduction	04.51%	95.49%
2018	Classification of living things	11.90%	88.10%
2019	Transport of materials in living things	04.80%	95.20%
2020	Classification of living things	01.30%	98.70%
2021	Nutrition	07.87%	92.13%

Source: (URT;2015;2017a;2018a;2019a;2020a;2021).