

AN ILLUMINATIVE EVALUATION OF THE INFLUENCE OF TESSA SCIENCE OER USE ON PRE-SERVICE SCIENCE TEACHERS' PEDAGOGY

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ABSTRACT

The study was conducted to investigate how the use of the Teacher Education in Sub-Saharan African (TESSA) Open Educational Resources (OER) units improved pre-service Science teachers' pedagogy. The illuminative case study design was employed to collect data using semi-structured interview guide and document analysis. Purposive sampling technique was used to collect data from 18 pre-service teachers who used the TESSA Science OER units in teaching during their off-campus teaching practice. Data generated were analysed thematically. The findings were that pre-service teachers used the TESSA Science OER in teaching during the yearlong off-campus teaching practice because they were motivated by their Science tutors to use the innovation during the on-campus teaching. It also emerged in the study among others, that the use of the OER units enhanced pre-service teachers' understanding and practical use of child-centred pedagogy and pedagogy of mutuality. The use of the TESSA Science units also improved participants' confidence in teaching Science and exposed them to the use of varied and novel teaching techniques. Despite the above success stories, the high cost of ICT tools and poor or non-existing internet connectivity prevented the effective use of the innovation. The study recommended, among others, that management of OLA College of Education should look for funding to support students to acquire affordable ICT tools if the continuous institutionalisation of the TESSA OER remains its goal.

Keywords: TESSA science OER, science pedagogy, child-centred pedagogy, teacher quality, teacher education, pre-service teachers.

INTRODUCTION

The quality of teacher education has been an issue of concern in many developing nations, especially, in Sub-Saharan Africa due to pupils' poor academic achievement despite increasing enrolment. Researchers have commented that the nature of teacher training that goes on in some parts of Sub-Saharan Africa should be considered, as the approach used tends to be more teacher-centred (Acquah, 2018; Dole, Bloom & Kowalske, 2016). According to Msonde and Msonde (2019), this has resulted in many teachers' continuous use of the teacher-centred approach to teaching after initial teacher training with the consequent worsening of pupils' academic achievement. Fullan and Langworthy (2013) argued that students will become increasingly uninterested and unmotivated in the study of Science if teachers do not come up with better pedagogies. They contended that teachers needed to invent a new pedagogy, which require the use of innovative teaching and learning strategies that promote the acquisition of 21st century skills. *Murphy and Wolfenden (2013)* also commented that teachers were particularly crucial to ensuring high standards of pupil achievement. Accordingly, Stutchbury (2016) pointed out that nations in Sub-Saharan Africa need to consider putting in efforts to train teachers, who are committed to using appropriate pedagogy, to ensure that pupils' achievements are raised. A pedagogy, which places emphasis on both teachers and learners

engaging in the creation and use of knowledge in the teaching context, be put in place so as to improve teacher quality (Murphy & Wolfenden, 2013). This will ensure that teacher development and training, especially, for the teaching of Science is made a lifelong process (Ngman-Wara & Acquah, 2015). Murphy and Wolfenden (2013) further contended that the Teacher Education in Sub-Saharan Africa (TESSA) Open Educational Resources (OER) model a learner-centred pedagogy stipulated by the curricula of many Sub-Saharan African nations.

TESSA OER units are teaching, learning, and research resources that reside in the public domain and were released under an intellectual property license that permits their free use or re-purposing by others (Atkins, Brown & Hammond, 2007). According to Stutchbury (2016), the idea behind the TESSA OER is to improve teacher quality and quantity through the production of open learning materials online. The TESSA OER are a large bank of highly structured, activity-based study units which teachers, can work through with pupils in their own classrooms (Wamutitu, Keraro, Changeiywo & Cullen, 2011). The TESSA OER bank consists of five subjects which are taught at the primary school levels and Science is one of these subjects. However, at the secondary school level, only Science OER has been developed as of 2019.

The TESSA OER specifies an inclusive activity-based pedagogic approach to teaching and learning (Harley & Barasa, 2012; Wambugu, Stutchbury & Dickie, 2019), which enables both teachers and learners to create and share knowledge. It could be argued that the inclusive activity-based pedagogy is what is deficient in teacher preparation programmes that are run by teacher education institutions in Sub-Saharan Africa in general, and Ghana, in particular (Akeampong, 2003). Considering the experimental nature of Science, its teaching requires the use of learner-centred and inquiry-based pedagogies. This, therefore, informs the need for such pedagogies to be promoted through teacher preparation programmes in the African sub region since the use of the TESSA OER has shown to engender learner-centred and inquiry based-pedagogies (Harley & Barasa, 2012).

OER developed by the TESSA project have been implemented in some higher educational institutions in countries that formed the consortium in Sub-Saharan Africa, including Ghana. The University of Education, Winneba and the University of Cape Coast were the initial higher education institutions in Ghana to partner the TESSA Consortium to run the TESSA OER project. These institutions have implemented the TESSA OER using varied strategies. The University of Education, Winneba introduced the innovation into some of its programmes (Harley & Barasa, 2012) and the University of Cape Coast introduced Our Lady of Apostles (OLA) College of Education to the TESSA OER (Acquah, 2018). Some studies conducted on the use of the innovation at the University of Education, Winneba revealed the tremendous influence of the material on the quality of teachers trained (Harley and Barasa, 2012; Ngman-Wara & Acquah, 2015). However, from the review of the literature carried out so far, it seems no research work has been conducted to investigate how TESSA Science OER influences pre-service Science teachers' pedagogy in the context of OLA College of Education. This study therefore set out to fill this gap. So the purpose of this study is to find out how the use of TESSA OER improved pre-service Science teachers' pedagogy. The research questions that guided the study were:

1. What were the trajectories through which pre-service teachers became aware of the TESSA Science OER?
2. How did pre-service teachers in OLA College of Education use the TESSA OER innovation?
3. How did the use of the TESSA OER influence pre-service Science teachers' pedagogy?

4. What challenges were encountered in during the use of the TESSA Science OER in teaching?

Science teacher educators in Ghana will find this study useful because it will expose them to the TESSA Science OER and its use to support pre-service teachers' pedagogical practice.

LITERATURE REVIEW

There is a growing body of research that shows that learner-centred pedagogy is the best way of teaching, and leads to deeper understanding, sustained interest and motivation for lifelong learning of Science (Dole, Bloom & Kowalske, 2016; Msonde & Msonde, 2019; Ngman-Wara & Acquah, 2015). The learner-centred pedagogy emanated from the constructivists learning perspective based on Vygotsky's social constructivist views of learning, which places emphasis on activity, discovery, independent learning and social interaction (Alton-Lee & Nuthall, 2007; Msonde & Msonde, 2019). According to Alton-Lee and Nuthall (2007), interactions and active learning in the classroom are crucial in the learning process since they enable learners to experience the "zone of proximal development". The learner-centred pedagogy makes the use of participatory teaching approach a necessity from the social constructivist perspective as it enables learners to make meaning of what they learn through the interactions they have among themselves (Msonde & Msonde, 2019).

In a study conducted by Doe, Bloom and Kowalske (2016), they found out that the use of learner-centred pedagogy helped teachers to alter their classroom teaching as it helped learners to interact among themselves. This, they said, gave teachers a new understanding of how students learn as trust is nurtured, active student participation promoted and students' curiosity evoked through the use of the learner-centred pedagogy. In another study by Msonde and Msonde (2019), they reported that teachers' confidence to teach improved and their understanding about the learner-centred approach changed when they were introduced to varied strategies of using this pedagogy. The learner-centred pedagogy is the intended pedagogy in the Science curricula of most developing nations in Sub-Saharan Africa, however, there are challenges with implementation (Ngman-Wara & Acquah, 2015).

Research further shows that teachers are usually not exposed to practical and active learner-centred approach during initial teacher training and professional development programmes (Akyeampong, 2017; Dole, Bloom & Kowalske, 2016, Msonde & Msonde, 2019). Akyeampong (2017) argued that the content of teacher education and professional development programmes organised in most nations in Sub-Saharan Africa is often more theoretical and abstract than the practical knowledge they need in the classroom leading to a gap between theory and practice. Suggesting a way of bridging this gap, Darling-Hammond and Mclaughlin (2011) contended that teachers needed to be exposed to the same practical and active learner-centred way of learning in order to comfortably enact same in their teaching. It is for this reason that the TESSA OER in general and specifically the Science OER units were created.

The TESSA Science OER

The TESSA Science OER forms part of the 75 OER units developed by the TESSA Consortium. The TESSA Consortium is a network of teachers and teacher educators in Sub-Saharan Africa and coordinated by The Open University, UK. The focus of the network is to create a bank of open educational resources (OER), linked to the school curricula in Sub-Saharan Africa, and designed to support teachers and teacher educators in developing active approaches to learning (TESSA Website, n.d). According to Stutchbury & Ngman-Wara (2012), the TESSA Science OER was produced to first solve the issue of poor academic performance in Science, which

was created as a result of the theoretical pedagogy used by teachers in teaching the subject. The TESSA Science OER consists of primary and secondary units. There are three module areas in the TESSA Primary Science OER, which are sub-divided into fifteen (15) key scientific concepts labelled as sections. Each module has five (5) sections. Concepts presented in each section are in the natural sciences. The modules are designed to enhance the pedagogy of the Science teachers and Science educators through practical activities. It is assumed that repeated use of TESSA OER leads to teacher learning and improvements in practice (Harley & Barasa, 2012).

Further, the TESSA Secondary Science OER are primarily designed to improve upon lower secondary Science teachers' classroom pedagogical skills in the natural sciences. The contents of the TESSA Science OER units are mainly suggested instructions that allow teachers the option to adopt or adapt to meet the pedagogical demands of their local curricula. The TESSA OER units facilitate teacher resourcefulness and creativity required to foster the problem-solving abilities and the acquisition of relevant skills and attitudes by pupils (Stutchbury & Ngman-Wara, 2012). The curriculum framework of the Lower Secondary Science OER was designed to focus on key scientific concepts that are often known to be difficult to teach from various Science curricula in the Sub-Saharan Africa Region.

Studies conducted by Parker, Osei-Himah, Asare and Ackah (2018) and Little (2010) revealed that many basic school Science teachers in Ghana lack the confidence and competence for teaching Science. This lack of confidence is a result of dealing with difficult, abstract and challenging scientific concepts, and this, usually affects 'the what and how' they teach. However, in the evaluative study conducted by Harley and Barasa (2012), they found out that the use of TESSA OER has a potential of improving teachers' confidence and competence in nations south of the Sahara when used in teaching. The use of the OER units by teachers has also made child-centred, activity-based and reflective practice in Science instruction real and achievable. The study again revealed that the TESSA innovation fused theory and practise, shifted perception from teachers as 'know it all' to 'teachers as facilitators of learning' and greatly enhanced the relevance of pupils' learning experience. The use of TESSA OER promotes pedagogy of mutuality as both teachers and learners are allowed to talk, listen, challenge and accept, and teach and learn (Murphy and Wolfenden, 2013). Flinchbaugh (2011) asserted that pedagogy of mutuality creates respect for learner's decisions during the class discourse.

Furthermore, the TESSA Science OER units were found to afford the bridging of the gap between teachers' knowledge of Science and the knowledge of the appropriate pedagogy for its teaching (Harley and Barasa, 2012). Studies conducted by Muganda (2011) and Wambugu, Stutchbury and Dickie (2019) revealed that the use of the TESSA OER enhanced active participation of learners in the lesson process thus allowing teachers to promote interactive teaching. However, Muganda's (2011) study revealed there was a general lack of awareness about the TESSA OER and this affected its use among students of the Open University, Tanzania. Tarosa (2013) asserted that creating awareness among teachers and students, who are directly involved in using innovations help decrease the gap between what is known and unknown about the innovation. The lack of ICT tools in most primary schools across Sub-Saharan Africa, the high cost involved in acquiring ICT tools by individuals teachers as well as limited internet accessibility in schools have been identified as some of the challenges preventing the effective use of OER in general and specifically the TESSA OER units (Wambugu et al., 2019).

METHODOLOGY

The intrinsic case study situated in illuminative evaluation design (Ellis, 2003) was used in conducting the study. Participants in this study were 18 third-year Science teacher trainees of the OLA College of Education. All the prospective teachers were purposively sampled because they had used the TESSA Science OER during the period of their one-year internship teaching practice as such they had some information about the innovation. Data were collected from semi-structured interviews and participants teaching documents. The interview protocol contained six (6) items. The items solicited information on awareness of the TESSA Science OER, how the innovation was used, the impact of the Science OER use on Science teachers' pedagogy and the challenges encountered during the use of the innovation.

Interview sessions lasted between 30 to 40 minutes and all were audio recorded with participants' consent. The participants were purposively sampled because they used the TESSA Science OER during the one-year period of internship teaching practice. Further, three lesson notebooks and three long essays (project) of six randomly selected interviewees were collected to provide evidence of the use of the innovation in teaching during the period of teaching practice.

The study was set in the subjectivist paradigm therefore data generated from interview sessions and documents collected were analysed inductively. The audio-recorded interview data were transcribed verbatim and transcripts read over several times so as to gain deep understanding of meanings and actions within the data (Miles and Huberman, 1994). The transcribed texts were analysed by attaching codes to units of information (Cobern, 1993). Recurring codes were clustered into main categories and then codes/themes, which led to how the TESSA OER units were introduced to participants, how the OER units were used, the influence on pre-service science teachers' pedagogy and challenges encountered. Data obtained were presented using themes/codes. Trustworthiness of data was ensured through member checking and clear and accurate reporting of participants' responses. To ensure anonymity, pseudonyms were given to all participants.

RESULTS

Analysis of the interview and document data resulted in four main codes/themes: awareness, use, pedagogical effect of the TESSA OERs and challenges encountered. The results are therefore presented under these codes/themes.

Awareness of the TESSA Science OER

It is important for users to be aware of an innovation prior to its use (Muganda, 2011). Thus, participants were asked how they became aware of the TESSA Science OER prior to its use. Data obtained indicate they became aware of the innovation in 2013, the very year they gained admission into the College. Participants recounted that they were made aware of the innovation through many college activities such as orientation for first years, interaction with tutors in charge of TESSA activities and the Principal of the College, TESSA club activities and its study as a first year course. Sharing her experience on how she became aware of the TESSA OER during the orientation for first years, Nana, participant commented: *"I never heard about TESSA until I came to OLA in 2013. It was during the orientation for first years that the tutors in charge of TESSA came to talk to us about it"*.

Explaining how participants became aware of the innovation during club activities and as a course, Ivy said:

I got to know about TESSA when I was a first year student of OLA.

During that time my seniors were embarking on an excursion and they said it was for TESSA club members. Later, I found TESSA on the school's timetable as a course to be studied by all first years.

As participants shared their experience of how they became aware of the TESSA OER, Rose also added how she became aware of the TESSA OER through the interactions with the Principal of the College as:

One day, the Principal called me to her office and asked me what I have learnt about TESSA. I could not give her good any answers, so, she encouraged me to take the TESSA lessons very seriously because the OER units were full of activities, which will make me a good teacher. She later suggested that I join the TESSA club to learn more.

Use of TESSA OERS

Pre-service teachers were asked to indicate how they used the TESSA Science OER after they became aware of it. Responses obtained revealed that participants used the TESSA OER materials during on-campus teaching practice and the yearlong off-campus teaching practice. The majority of the participants (14 out of 18) indicated that they used the Science OER units in teaching during the on-campus teaching practice. Their motivation for using the OER units derived from Science tutors use of the innovation in teaching during the Science methods course in the second year. Thus, they became more exposed to the innovation and were therefore encouraged to use it in teaching during their on-campus teaching practice lessons. Sharing her experience on this, Mame Abena explained:

During the on-campus teaching practice period, I wanted to teach the topic 'density' and I wanted my lesson to be activity oriented. So one of our Science tutors encouraged me to visit the TESSA OER site to look for activities I could use for my lesson. I visited the TESSA site and got appropriate activities for my lesson.

Nyarkoa also said that Mr Alhassan (a Science tutor) always used the OER units in teaching his Science method lessons and so she was encouraged to use the TESSA units in writing her lesson plans during the on-campus teaching practice. She added:

We were taught how to log onto the website and the Science tutor always told us which activities he adapted/adopted from the TESSA site when teaching. So, I was motivated to also log onto the TESSA site with my topic to find the type of resources that could help me teach my lessons well.

Twelve participants (12 out of 18) also indicated that because they were guided to use the innovation during the Science method lessons and on-campus teaching practice they were able to use the TESSA Science OER effectively in teaching during the yearlong off-campus teaching practice. Rejoice for example said that because she used the OER during the period of on-campus teaching practice. She was able to use the innovation in teaching most of her Science lessons.. Dora also said that, *"the way the Science tutors exposed us to the TESSA Science units was very good. Because of that I was able to use TESSA when I went for my internship"*.

The use of innovations in teaching during off campus teaching practice was evident in the lesson notebooks collected. Data gleaned from samples of Science lesson plans revealed that some pre-service teachers adopted or adapted activities from the TESSA Science units in preparing their lessons, and others also cited the TESSA OER as reference materials for writing their lesson notes. Analysis of long essays collected from some of the participants also revealed

that topics and interventions used in conducting their action research were based on the TESSA Science OER. Some long essay topics identified include: 'Using TESSA OER to improve the performance of basic 7 pupils in the concept of electricity production at Saltpond Methodist B'; 'Using TESSA to improve the understanding of living things among basic three pupils of Kormantse Methodist A' and 'Using TESSA OER to improve performance of basic five pupils on effects of light energy on objects at Amosima Catholic Basic'.

Pedagogical Influence

The main focus of this study was how the use of the TESSA Science OER improved pre-service teachers' Science pedagogy. Interview data gathered revealed four sub-themes/codes under pedagogical influence which are child-centred pedagogy, pedagogy of mutuality, improved teacher confidence and exposure to varied teaching techniques. Thus, the results are presented and discussed under these sub-themes/codes.

Child-centred pedagogy

There is advocacy for the use of child-centred approach in teaching Science as it involves the engagement of learners in hands-on activities. It is a pedagogy that also ensures active participation and fosters understanding of what is taught. Thus, any innovation that enables teachers to acquire the knowledge and practical skills needed to implement the child-centred approach of teaching Science is worthwhile.

Responses obtained from all participants during the interview sessions revealed that the use of the TESSA Science OER improved their understanding and practice of child-centred pedagogy. Sharing her experiences, Isabel remarked:

Even though we were told in school that when you are teaching, it shouldn't be teacher centred but it should be child-centred. I did not understand what that meant till I used the TESSA. Whenever I use TESSA materials to teach, all the pupils are involved in one activity or the other. The materials are actually filled [sic] with many activities for children to do.

Half of the participants specifically expressed how their lesson became interactive, interesting and enjoyable to the children and themselves when they used the TESSA OER in teaching. Rejoice described her experience this way: *"TESSA lessons are full of activities therefore pupils are always involved in what you are doing. This makes the lesson very interactive and interesting. The pupils always enjoy such lessons and so do I"*.

A few of the participants (5 out of 18) however, indicated that sometimes the use of child-centred method of teaching is not always dominant in a lesson when you use the TESSA OER in teaching. Expressing their concerns, the participants pointed out that sometimes the subject and topic to be taught determined which method of teaching to use. In sharing her views, Rose remarked:

Sometimes the teacher's activity becomes more than the learner activities in certain lessons when the learners are not able to do what they are expected to do well. When this happens you the teacher, have to perform the activity again for the child to understand what you expect him/her to do. So it is not always that child activities are more. When the learners don't understand what you want them to do, you have to talk more and do more till they understand.

Promoted Pedagogy of Mutuality

Eight of the participants also indicated that the use of the Science OER promoted mutual learning during lesson delivery and changes the way the teacher works in class. They noted

that because pupils are allowed to communicate and interact, they are able to come up with new ideas and share what they learn with friends and their teacher. Thus, the teacher is no longer seen as the only one with knowledge to share. Some of the participants even noted that sometimes they learn new things from the pupils. On the issue of how the use of the TESSA OER changes the way the teacher works, Isabel shared her experience as:

The use of the OER changes the way a teacher works. It shows you how to allow pupils to communicate and interact among themselves and materials that are brought to class, for them to understand the concept being taught. When you use TESSA it shows you how to allow the pupils to be in control of what goes on in the class and you look on and guide them.

Adding to this Ayisa also commented:

I thought that the teacher should always be the one who has control and impart knowledge to pupils. You see, we say the teacher teaches and the pupil learns. That's what I knew. But when you use the teaching strategies in the TESSA OER, you sometimes allow the pupils to have control and find out things for themselves. You allow them to explain why they disagree with certain things you have taught them. As a matter of fact, you give them control in the class. So the teacher does not always have all the control but become a guide.

Commenting on how the use of the TESSA OER allows teachers to learn from their pupils and promoted mutual learning among pupils, Ama revealed: *"I sometimes learn new ideas from my pupils when they perform activities suggested in the TESSA. My pupils actually teach me things I have never thought of"*. Maggie also added that: *"TESSA lessons are very interactive and this creates opportunity for pupils to share their ideas and they learn from one another"*.

Improved Teacher Confidence

Almost half of the participants (8 out of 18) mentioned that their confidence to teach has been boosted since they began using the innovation during the off-campus teaching practice. Some of the pre-service teachers shared the view that initially they did not have confidence in their ability to teach, but that changed when they were introduced to the TESSA OER. Others also stated that getting acquainted with the Science OER units by constantly reading them builds one's confidence. Describing her experience, Rejoice noted how she did not want to become a teacher because she felt she did not have the confidence but accepted to be trained because her parents asked her to. She, however, indicated that: *"My confidence to teach boosted after we were introduced to the TESSA OER and I began reading more about it"*.

Sarah also shared her experience:

Before I was introduced to TESSA, I was scared of teaching Science because I felt it was a difficult subject to learn therefore teaching it would be more difficult. But when I got introduced to TESSA and I started using the strategies in it to teach, I picked up interest in teaching Science. Now I am very confident of myself.

Exposure to Varied Teaching Techniques

Some of the participants (8 out of 18) commented that using the Science OER exposed them to varied and many teaching techniques, some of which were new to them. They added that sometimes when they used varied teaching techniques in a single lesson, pupils became excited and showed lots of interest in such lessons, which eventually made the pupils to understand what was taught. Other pre-service teachers also commented that the TESSA units provided extra information on activities that helped teachers to prepare well for lesson presentation. They

continued that this was not the case in most activities found in the basic school Integrated Science textbooks.

Challenges Encountered

Participants in the study discussed specific challenges they faced while using the TESSA Science OER during the yearlong teaching practice. Many of the challenges stemmed from financial constraint associated with acquiring ICT tools, while others pertained to unreliable or non-existing internet connectivity. In total, five participants indicated that they faced problems with the use of the TESSA Science OER due to financial constraints. They lamented that their poor financial position prevented them from acquiring ICT tools such as computers, tablets, smart/android phones, and also could not allow them to afford internet bundles to access the OER for teaching during the yearlong teaching practice. Sarah described her frustration:

You see, TESSA in an online material and you need a computer or smart phone with internet connectivity to access the units. As a student, I don't have money to buy these things so I always asked my supervisor to print hard copies of TESSA material for me to use.

For six of the participants, they were not able to use the TESSA OER effectively due to unreliable or non-existing internet connectivity. Expressing their challenge, Mary said:

It is not everywhere that we have internet. I did my teaching practice in a village and at that place the internet was not stable at all. Sometimes you want to search for information on TESSA from the net and then it will go off.

DISCUSSION

The findings from this study show that prior to the use of the TESSA OER, Management of OLA College of Education made efforts to create awareness among pre-service teachers who had to use the innovation to improve their pedagogy. The awareness creation was done through various school activities and this obviously made it easier for the pre-service teachers to use the TESSA Science OER in teaching during the period of on-campus teaching practice and subsequently during the yearlong teaching practice. This finding concurs with Tarosa's (2013) assertion that creating awareness among teachers and students who are directly involved in using an innovation helps to decrease the gap between what is known and what is not known about the proposed change.

It was also revealed from this study that pre-service teachers not only had a better understanding of the child-centred pedagogy but also were able to put it into practice during the yearlong teaching practice. Transforming teachers' pedagogy from traditional teacher-centred approach to a child-centred one, characterised by engaging learners in hands-on and interactive activities, is not an easy task. In this case, the TESSA Science OER served as a useful resource for engaging pre-service teachers to make child-centred and activity-based lessons real and achievable as indicated by Harley and Basara (2012).

In addition, the use of TESSA OER boosted pre-service teachers confidence for the teaching of Science. This finding contradicts what happens practically among most basic school Science teachers in Ghana as reported by Parker, Osei-Himah, Asare and Ackah (2018) and Little (2010). According to these researchers, most basic schoolteachers lack confidence in teaching science as a result of the difficulties such teachers face in understanding scientific concepts.

These researchers are of the view that teachers see some scientific concepts as challenging and abstract to grasp.

With their newfound confidence and excitement about teaching Science using the TESSA OER, pre-service teachers still encountered some challenges while using the innovation. The challenges they encountered included financial constraints in acquiring ICT tools and unreliable or non-existing internet access. The TESSA OER units are online-based, and require internet service provision for its accessibility. Internet connectivity at some of the locations where participants did their off-campus teaching were either unreliable or non-existent, and this affected the use of the TESSA Science OER. This finding is consistent with that of Wambugu et al. (2019). In their study, they found out that the high cost involved in acquiring ICT tools by individual teachers, as well as limited or non-existing internet accessibility affected the effective use of the innovation.

CONCLUSION

The purpose of this study was to find out how the use of the TESSA Science OER improved pre-service Science teachers' pedagogy. The study also looked at how the TESSA OER units were used by participants. The findings attest to the fact that pre-service teachers used the TESSA Science OER in teaching during the period of on-campus teaching practice and the yearlong teaching practice. The findings further reveal the use of the TESSA Science OER enhanced pre-service teachers' teaching pedagogy in four major ways. It improved their understanding of the child-centred pedagogy and pedagogy of mutuality, enhanced their confidence in teaching Science, and exposed them to varied teaching techniques. However, the study reveal challenges such as financial constraints and poor or non-existence of internet connectivity as factors which prevented the effective use of the TESSA Science OER during the year-long teaching practise.

RECOMMENDATIONS

The TESSA OER units possess the potential to enhance pre-service teachers' pedagogical practises and skills. This has been proven by pre-service teachers confirmation of the influence of the TESSA OER on their Science pedagogy. The improvement in pre-service teachers pedagogy portends to a huge prospect in improving female participation and representation in Science in the educational context. Considering that there are fewer female Science teachers at all levels of the educational system in Ghana, the TESSA Science OER has the potential to transform Ghana's situation. This is because OLA College of Education is the only Female college of education in the Ghana, which trains female Science teachers for the basic education level. As revealed in the study, the use of the TESSA OER also boosted pre-service Science teachers' confidence and competence thus when these get translated into their classroom practice in future, it will make them good role models. These role moles will encourage female pupils to develop interest in the studying of Science and its related courses beyond basic education.

In today's world, ICT knowledge has become critical and information access has become a key characteristic of lifelong learners. The TESSA Science OER has shown to predispose teachers to the culture of accessing educational information which is a lifelong learning skill. This will be a departure from their orientation to access information solely from printed books and other printed educational resources.

To realise the prospects and ensure pre-services teachers' continuous use of the TESSA Science OER, the following recommendations are made. First, I recommend that Management of the College should continue to create awareness of the TESSA Science OER among all first year students when they gain admission into the College. Management of the College should also encourage all Science tutors to use the Science OER in teaching their courses so that all pre-service teachers of the College will be encouraged to use the innovation in teaching during the on-campus as well as the yearlong off-campus teaching practice.

Second, to address challenges which hinder access to the TESSA Science OER units, I recommend that Management of the College, in the interim, puts the online materials on flash drives and distribute them to all pre-service teachers who may not have the device or access to internet connectivity prior to their off-campus teaching practice. Also, pre-service teachers who possess smart phones or android phones should be encouraged to download the TESSA Science OER units unto their phones so it could be accessed off line to offset the challenge associated with unstable or non-existence internet network. Again, the College should make hard copies of selected materials that would be used by pre-service teachers available for those who cannot afford the acquisition of ICT tools. Lastly, the College can look for funding to support students to acquire affordable ICT tools if the continuous institutionalisation of the TESSA Science OER remains its goal.

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