TESSA Science OER Reflections of the Profile Dimension for Teaching Basic School Science in Ghana

Dr. Sakina Acquah
University of Education, Winneba
efuaacquah@yahoo.com

Abstract

The purpose of this study was to examine how specific objectives stated in the TESSA science OER reflect the profile dimensions for teaching basic school science in Ghana. The TESSA science OER have been developed based on the science curriculum of schools in sub-Saharan Africa region to promote effective science teaching. Ghana is one of the partnering countries, which helped in the development of the TESSA OER and have initiated its implementation. The qualitative descriptive design was employed for the study and document analysis was used as the data collection tool. In all 30 TESSA science OER units were examined. Probing the TESSA science OER based on the curriculum developers' requirements, it came to light that more emphasis has been placed on some of the profile dimensions in the TESSA science OER than what is seen in the Ghanaian basic school science curriculum. It is recommended that workshops and in-service training on the use of the TESSA science OER be organised for basic school science teachers, to assist basic school learners attain some level of scientific literacy. This feat would enhance learners' interest and also help them to develop a positive attitude towards studying science beyond the basic school level.

Key words: basic school level, profile dimensions, science curriculum, scientific literacy, TESSA science OER.

Introduction

Most countries in sub-Saharan Africa place emphasis on learner-centred education, which is characterised by active learning approaches in science, mathematics and technology curricula (Ngman-Wara & Acquah, 2015). But these approaches are often not implemented. Science teaching in most primary schools in sub-Saharan Africa is often characterised by teacher-centred approaches to teaching due to the lack of teaching resources (Asari & Nti, 2014), pressure on teachers to complete the already overloaded curriculum, teachers lack of self confidence in the subject matter (Verspoor, 2008) and the examination oriented nature of the school system (Acheampong, 2003).

Studies conducted by the United Nations Educational, Scientific and Cultural Organisation [UNESCO] (2005) pointed out that many pupils leave school without mastering a minimum set of cognitive and non-cognitive skills. Schaefer (2000) also argued that African countries are among countries with less than 50% of its children achieving literacy, numeracy and life skills mastery after year four of their educational experience. These findings generated variant remedies of which the Teacher Education in sub-Sahara Africa (TESSA) programme emanated in 2005. There is evidence that the initial project has made an impact across sub-Saharan Africa (Harley & Barasa, 2012).

TESSA is a demand-led research and development project providing a practical and scalable response to the huge need for more qualified and skilled teachers in sub-Saharan Africa (Moon, 2007; Wolfenden, 2012). TESSA, which focused on solving this challenge, was centred on the creation of a rich set of open educational resources, which could be adapted for multiple contexts and cultures to support classroom-focused teacher development (O'Sullivan, 2006). Its aim is to support teacher educators and teachers in improving teaching practices through a focus on promoting effective pedagogy (Hardman, Ackers, Abrishamian & O'Sullivan, 2011; Murphy & Wolfenden, 2012). From its inception, the TESSA Open Educatioanls Resources (OER) has provided teachers with learning and professional knowledge, which is supported by gradual and highly structured participation in the practice of teaching, rather than the internalisation of discrete, prescribed teaching skills and competencies (Leach & Moon, 2008). TESSA activities actively engage learners, eliciting new responses, which encourage teachers to further develop their practice (Murphey & Wolfenden, 2012).

So far, the orientation behind the creation of the TESSA OER has yielded some good results (Harley & Barasa, 2012; Murphy & Ngman-Wara & Acquah, 2015). Essential among them includes the fact that the content of the TESSA OER materials are suitable for basic school teachers, and for teacher educators as well, who train and expose experiences to pre-service teachers or in-service teachers. This makes the OER an ideal material for the upgrading of a variety of educational programmes in various levels of education in sub-Sahara Africa. Further, the TESSA materials are designed based on the constructivist theory that proposes active participation and student inquiry. This is an indication that the TESSA OER makes applicable both the knowledge and sociological perspectives of scientific literacy. This system of teaching is believed to increases teacher's confidence and addresses other challenges teachers face in the process of teaching science (Harley & Barasa, 2012).

Scientific literacy defines what the public should know about science in order to live more effectively and efficiently in the world (DeBoer, 2000). According to Dani (2009), scientific literacy consists of the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity. Promoting scientific literacy accrue benefits to national economies science itself, science policy-making, and democratic practices, as well as to society as a whole. It is in this light that successive governments have shown commitment by making scientific literacy compulsory in all the various educational reforms in Ghana (Anderson, 2006). In the context of the basic school science curriculum, the acquisition of scientific literacy is dependent on the teacher's ability to translate the specific objectives and profile dimensions into teaching activities for learners. Nonetheless, Vieira, Melo, Avraamidou and Lobato (2017) argued that the acquisition of scientific literacy has been an issue of concern because methods on how it can be acquired still lack convergence.

Studies carried out to check on the specific objectives in the basic school science curricula and the profile dimensions using the 2002, 2012 basic school science curricula found out that the specific objectives did not match the intended profile dimensions, which is envisage to promote scientific literacy (Acquah, Acquah, Yakubu & Osei-Yebaoh, 2018; Ghartey-Ampiah, 2006). The TESSA science OER has been found to promote scientific literacy, and basic school teachers in Ghana are being encouraged to adapt or adopt its teaching strategies to enhance their teaching pedagogy so as to improve achievement in science (Ngman-Wara & Acquah, 2015). According to Harley and Barasa (2012), OLA College of Education and UEW all in Ghana have incorporated the TESSA modules into some of the programmes they offer for pre-service teachers. Despite the above, there is a research gap on how the profile dimensions stipulated in the 2012 basic school science curriculum match that in the TESSA science OER.

This study therefore sought to examine how specific objectives stated in the TESSA science OER reflect the profile dimensions for teaching basic school science in Ghana. The research question that guided the study was, how does the TESSA science OER reflect the profile dimensions in the Ghanaian basic school science curriculum?

The Ghanaian basic school science curriculum and profile dimension

The Ghanaian basic school science curriculum comprises Natural science, taught at the lower primary level (p1 to p3) and Integrated science taught at the upper primary (p4 to p6) and junior high school (JHS 1 to 3) levels. The concept of profile dimension, a collection of psychological units of a particular learning behaviour is considered as the central aspect of the basic school science curriculum expected to guide teaching, learning and assessment (MOE, 2012). Profile dimension is an action verb that constitutes specific objectives stated in science curriculum (MOE, 2007). At the primary school level, the profile dimensions expected for the teaching, learning and testing of Natural and Integrated sciences are the same. The profile dimensions with their stipulated percentage weightings are knowledge and understanding (20%), application of knowledge (20%), and attitude and process skills (60%).

It can be seen that a lot of emphasis has been placed on attitude and process skills than the others. This is because curriculum planners expect teachers to plan and execute varied activities during the teaching and learning process, to enable pupils to acquire the necessary scientific process skills needed to build their store of scientific concepts and principles (MOE, 2012). At the JHS level, the expected profile dimensions specified for the teaching, learning and testing of Integrated science are slightly different from that of the primary level. The expected profile dimensions with their stipulated percentage weightings are knowledge and comprehension (20%), application of knowledge (40%), and experimental and process skills (40%). This shows an emphasis on the application of knowledge, experimental and process skills, for which teachers are expected to plan and execute activities to enable learners to acquire these dimensions during the teaching, learning and testing process.

A critical look at both curricula reveals the importance placed on attitude and process skills at the primary school level and application of knowledge, experimental and process skills at the JHS level. The marked difference in the profile dimensions at the two levels is as a result of the fact that at the primary level, pupils are expected to be equipped with the necessary process skills and attitudes that would introduce them to the enquiry process of science. At the JHS level, pupils are expected to physically explore and discover so as to gain experimental and process skills, and apply scientific knowledge (MOE, 2012). Attitudes/ experimental and process skills, as well as application of knowledge that Ghanaian primary and junior high school children need to develop through the study of science are in the form of specific objectives and suggested activities. These are stated in the science curricula, and serve as a guide for the teacher (Acquah, et al, 2018). It is these specific objectives and suggested activities which are expected to reflect the different percentage weights of profile dimensions as specified in the basic school science curricula. Based on the above, it will be prudent to look at TESSA Science OER and how it relates to or reflects the profile dimension in the basic school science curricula.

The TESSA Science OER

The TESSA Science OER consist of primary and secondary OER. There are three module areas in the TESSA Primary Science OER, namely; *Looking at life*; *Investigating Materials*; and *Energy and movement*, which are sub-divided into fifteen (15) key scientific concepts labelled as sections. Each module has five (5) sections. A critical assessment of the content of the various modules shows that each of the sections collated are also inspired by the concepts of the natural sciences. In light of that, sections in the module "Looking at Life" are mainly Biological concepts, that of "Investigating Materials" are basically concepts of the topic "matter" in Chemistry and that of "Energy and movement" are inspired by the concept in Physics. The modules enhance the pedagogy of the science teacher or the science educator through practical activities. Repeated use of TESSA OER leads to teacher learning and improvements in practice.

The TESSA Secondary Science OER are primarily designed to improve upon lower secondary science teachers' classroom pedagogical skills in the natural sciences, on the themes; Biology, Chemistry and Physics. The contents of the OER are suggestive instructions offering teachers who adopts or adapt them, an alternative pedagogy similar to their local curriculum. These themes emerged from discussions surrounding the need for teachers (particularly in Africa) to be resourceful and creative, and from the belief that the ability to solve problems and to be creative are skills and attributes that should be fostered in pupils through the curriculum (Stutchbury & Ngman-Wara, 2012).

The curriculum framework of the Lower Secondary Science OER was designed to illustrate five pedagogical themes in Biology, Physics, and Chemistry. Key scientific concepts, which are often known to be difficult to teach from various science curricula in the sub-Saharan Africa region were identified under these five pedagogical themes. The five themes are; probing children's understanding/learning, making science practical, science lived (relevant and real), problem solving – creativity – innovation in science and dealing with challenging ideas in science.

The content of each TESSA Science OER section for both primary and secondary levels are designed in the same pattern. Table 1 describes the various headings that come with each section of TESSA science OER. In each section, there are statements of practical activities expected to illicit learning from pupils. Some of these statements are directed towards the teacher, but there are some that clearly indicate what is expected of the learner as well. These activities include the pedagogical skills teachers have to adopt or adapt and the roles expected of students in order to achieve set learning outcomes. For example, in the Module 2 of the TESSA Primary Science Resource, Section 5, the statements in the boxes were extracted from activities 1, 2 and 3.

Table 1: Content of the TESSA science OER section

Content	Description of Content
Key Focus Question	This is addressed to the teacher and summarises the area to be studied in the section.
Learning Outcomes	Each section has a maximum of three learning outcomes stated for the teacher. They centre on the development of classroom skills in the context of the curriculum of that module area.
Introduction	The introduction sets the scene for the section. It outlines classroom skills to be developed by the teacher and the curriculum content area across the section.
Narrative	The narrative of each section provides a rationale for the case studies and activities and highlights the purpose of each. It may briefly describe a relevant theoretical perspective, additional subject knowledge for the topic or the location of additional supporting resources.
Case Studies	Every section has three case studies, each linked to a particular activity. The case studies illustrate ideas and concepts by describing how one teacher has approached the linked activity or a similar activity in her/his classroom. They may often focus on one particular aspect of the activity or on a particular classroom situation – for example working with a multi-grade class, with very large numbers of pupils or in particularly challenging circumstances.
Activities	Each section has three activities which forms the core of each section. They offer activities for the teacher to undertake in their classroom, with pupils or in the wider school and community. The activities build towards the final activity, known as the *key activity*. The activities are all learner centred and highly engaging for pupils. Some activities are very short – perhaps a twenty minute task – whilst others are projects stretching over several weeks. The majority should occupy one lesson just as the Ghanaian Primary Science curriculum activities spans in time.
Resources	Each section has up to six supporting resources. These can take a variety of forms including web links, articles, images, stories, and posters, examples of pupils' work, detailed lesson plans, worksheets and template documents. They are chosen to enrich the teachers' learning and support their delivery of the activities. The resources support the development of different dimensions of a teacher's knowledge base, including: • content knowledge • pedagogical knowledge and • pedagogical content knowledge. A few of the resources are intended for use with pupils. Icons are used to show the core purpose of a resource. These are: • pupil use • background information / subject knowledge for teachers • teacher resource for planning or adapting to use with pupils • examples of pupils' work.

Source: TESSA Programme, 2016

Box 1: Activity one

…ask each group to research a different group of products…

Box 2: Activity two

… pupils should write these in their books…

Box 3: Key Activity (Activity three)

…ask each group to present their product to the class …

Source: TESSA Programme (2016)

Also, in the Secondary Science Resource, examples in activities one, two and three of section 1, in the Physics context, present the following excerpts that describe what is expected of students.

Box 4: Activity one

…ask them to work in groups of four to discuss how the objects can be classified…

Box 5: Activity two

…they have to be able to justify their answers …

Box 6: Activity three

…make your students observe carefully and then get them to try and explain their ideas…

The critical assessment of the excerpts in the boxes indicates an action verb in each excerpt that describes some of the learning outcomes expected of learners or some of the specific activities required of learners in each activity. It was from such statements directed towards the learner that the researcher chose the verbs that maps to the verbs of the profile dimensions in the Ghanaian Basic School Science Curriculum. In the excerpts from box 6, in activity three, the researcher selected the key verbs "*observe*" and "*explain*" as the main action verbs that describes the dimension expected of pupils for that activity.

Methodology

In conducting this study, the researcher opted for the used of qualitative descriptive design (Colorafi & Evans, 2016; Sandelowski, 2010) and collected data using the document/content analysis. All modules in the TESSA Primary and Secondary science OER materials were used. In total, the content of 30 TESSA science OER sections, which comprised of 15 primary and 15 secondary level OER units were analyzed. After a critical study of the activities in the TESSA science OER, all the main verbs identified were classified under the three main profile dimensions; Knowledge and Understanding/Comprehension, Application of Knowledge, Attitude and Process skills, as stated in the basic school science curriculum. Action verbs describing these profile dimensions were sampled and sorted under the appropriate profile dimension, thus, either Knowledge and Understanding/Comprehension, Application of Knowledge or Attitude and Process Skills. Moreover, the descriptions of the various profile dimensions and the examples of verbs that fall under each of them are explicitly described under the preamble of the Ghanaian Basic School Science Curriculum. For instance, from the excerpt in box 1 under the TESSA Primary Science OER, the teacher was tasked to ask pupils to "research" a different group of product. The verb "research" was selected as the main action verb of the learning activity and based on the descriptions of the various profile dimensions in the Ghanaian Primary Science Curriculum, the verb was placed under "Attitude and Process Skills".

There were some verbs used in the TESSA OER (like *test*, *mime*, *read*, *role-play*) as well as phrases (like '*make a guess*', '*note down*', '*find examples*' etc.) that describes activities pupils will be engaged in but were not found among the verbs indicated under the profile dimensions in the basic school science curriculum. With such verbs and phrases, clarity was sought from the descriptions of the various profile dimensions as described in the basic school science curriculum, and from science lecturers in the Science Education Department of the University of Education, Winneba and based on the import of the activities, the researcher classified them under the most appropriate profile dimension. Descriptive statistics was used in analysing data generated and results were presented using frequency counts, percentages and bar charts.

Results and Discussions

Proportion of specific objectives in the TESSA primary science OER addressing the three profile dimensions in the primary science curricula

The TESSA Primary Science OER was developed to integrate both teacher and learners required activities. The roles played by these two factors are explicitly written in each activity. The expected psychological behaviour expected of pupils is indicated in each activity, whiles the roles of teachers to facilitate the eliciting of such behaviours are also indicated. The distribution and percentage weighting of profile dimension specified for teaching, learning and testing by the Ghanaian Natural and Integrated science curricula are; Knowledge and Understanding 20%, Application of Knowledge 20% and Attitude and Process skills, 60%. Per the distribution prescribed by the Ghanaian Natural and Integrated Science 2012 syllabuses, the researcher mapped the distributions of learning outcomes in the TESSA Primary Science OER to the various profile dimensions to measure how they weigh relative to the weightings the Ghanaian syllabus has prescribed.

The content analysis of the 15 sections in the 3 modules of the TESSA Primary Science OER showed 208 specific objectives pupils were expected to perform or experienced in a given activity in the modules. The summary of the distribution of the learning outcomes expected of learners in the TESSA Primary Science OER classified based on the outline of the profile dimensions in the Ghanaian Primary Science Curriculum is outlined in Table 2.

Table 2: Actual percentage weights of the three profile dimensions in the TESSA science primary OER

	Modules in the TESSA OER							
	Module 1		**Module 2**		**Module 3**		**Total**	
Profile Dimensions	**№**	**%**	**№**	**%**	**№**	**%**	**№**	**%**
Knowledge and Understanding	7	9.86	9	13.85	11	15.28	27	12.98
Application of knowledge	19	26.76	19	29.23	26	36.11	64	30.77
Attitudes and Process Skills	45	63.38	37	56.92	35	48.61	117	56.25
Total	**71**	**100**	**65**	**100**	**72**	**100**	**208**	**100**

Source: TESSA Programme, 2016

Table 2 shows the distribution of all the sampled learning outcomes expected of only learners in each activity in the 3 modules of the TESSA Primary OER. It also indicates the sorting of the learning outcomes based on the profile dimensions spelt out in the 2012 Ghanaian Primary Science Curricula. From Table 2, out of the total number of 208 learning outcomes counted, 27 (12.98%) were on Knowledge and Understanding, 64 (30.77%) were on Application of Knowledge and the remaining 117 (56.25%) were on Attitudes and Process Skills. This distribution reflects a tilted distribution with emphasis on Attitudes and Process Skills exactly as prescribed by the Ghanaian Primary Science Curricula. Comparing the distributions of the 'Knowledge and Understanding" and "Application of Knowledge", the Ghanaian Curriculum, prescribed an equal distribution between the two, but the distribution as shown in Table 2 reveals a difference of 17.79% between them, with Application of Knowledge leading with 30.77% and Knowledge and Understanding trailing with 12.98%. Figure 1 also shows a graphical distribution of the actual profile dimensions in the TESSA OER mapped against the expected profile dimensions in the Ghanaian Primary Science Curricula.

Although, there is little evidence of formulated curriculum ideals to promote science learning (Verspoor, 2008), the TESSA Primary Science OER promotes science learning and scientific literacy as it places emphasis on learner-centred education. Thus, pupils will be exposed to more attitude and process skills as they are taught using the TESSA OER. This is line with Ngman-wara and Acquah (2015) view that active learning approaches characterizes the TESSA science curriculum.

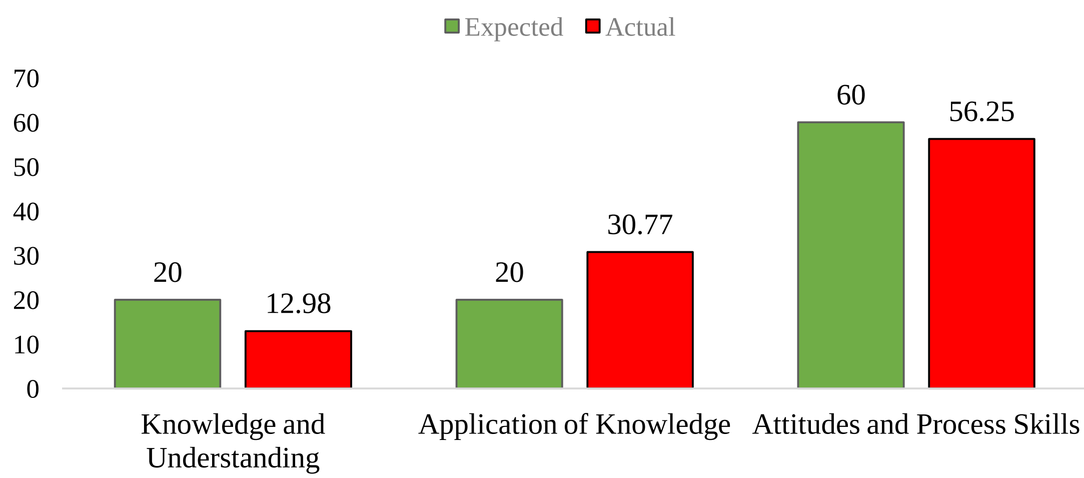

Figure 1: Expected and actual percentage weights of the profile dimensions in TESSA primary science OER

Proportion of specific objectives in the TESSA lower secondary science OER addressing the three profile dimensions in the JHS science curricula

The dimensions for teaching, learning and testing in Integrated Science at the JHS and their respective percentage weights are; Knowledge and Comprehension 20%, Application of Knowledge 40% and Experimental and Process skills 40%. Each of the dimensions has a percentage weight of objectives that should reflect in teaching, learning and evaluation activities. The weights have a high inclination of the profile dimensions towards "*Application of knowledge*" and "*Experimental and Process Skills*" with equal percentage weights of 40%.

The content analysis of the 15 sections of the TESSA Lower Secondary Science OER reflected 126 specific objectives directed at students, which are spread across the Biology, Physics and Chemistry contexts. Table 3 shows a summary of the distribution of the learning outcomes in the TESSA Lower Secondary Science OER expected of learners matched to the profile dimensions outlined in the JHS Integrated Science Curriculum.

Table 3: A distribution of learning outcomes in the TESSA lower secondary science OER matched to the profile dimensions outlined in the Ghanaian JHS science curriculum

	Themes in the TESSA OER							
	Biology		**Physics**		**Chemistry**		**Total**	
Profile Dimensions	**№**	**%**	**№**	**%**	**№**	**%**	**№**	**%**
Knowledge and Comprehension	15	31.25	18	37.50	15	31.25	48	38.10
Application of Knowledge	14	37.84	10	27.03	13	35.13	37	29.36
Experimental and Process Skills	13	31.71	19	46.34	9	21.95	41	32.54
Total	**42**	**100**	**47**	**100**	**37**	**100**	**126**	**100**

Source: TESSA Programme, 2016

Among the three contexts of the TESSA Lower Secondary Science OER, it was revealed that, the profile dimensions were intertwined such that as pupils acquire content knowledge they also apply the knowledge in diverse ways in the form of activities; process skills are also integrated as well. Analysis of the profile dimensions in the TESSA Lower Secondary Science OER showed a wide spread distribution of dimensions that forms the basis of learning outcomes among the three contexts in the TESSA Lower Secondary Science OER.

The distribution in Table 3 also shows an emphasis on knowledge and comprehension with 38.10% of the total learning outcomes evaluated, this is closely followed by "experimental and process skills" with a percentage of 32.54% and then application of knowledge with 29.36%. Although this trend does not conform to the expected profile dimensions spelt out in the Ghanaian JHS Science Curriculum, it promotes scientific literacy, which is consistent with DeBoer (2000) view. According to DeBoaer (2000), exposing the public to science knowledge in order for them to live an effective and efficient life constitutes scientific literacy. Figure 2 emphasize the distribution of "expected" profile dimensions in the TESSA Lower Secondary Science OER.

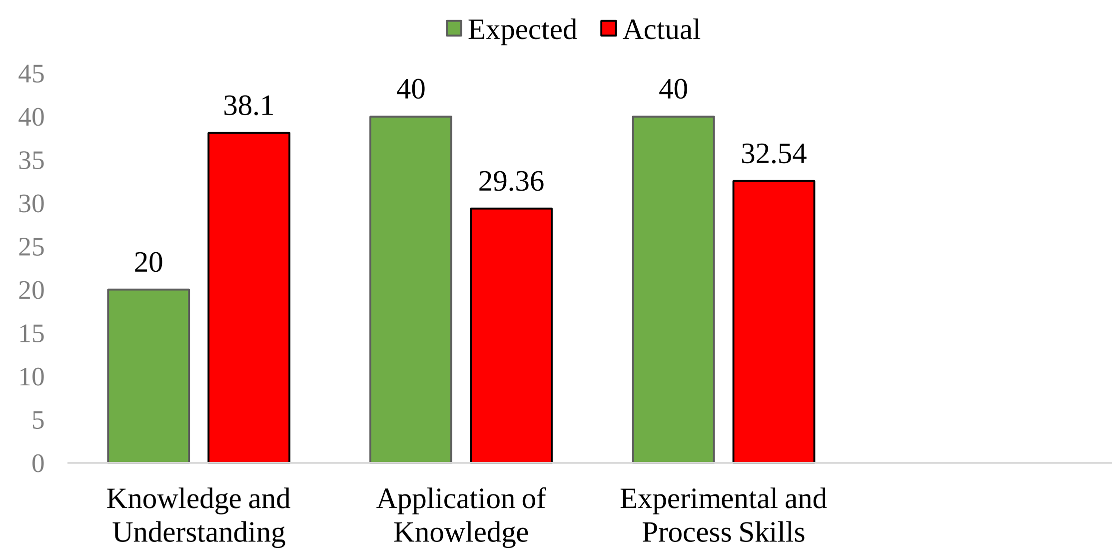

Figure 2: The Distribution of the expected profile dimension in the JHS science syllabus and the actuals in the TESSA lower secondary science OER

Inferring from Figure 2, the margin of discrepancy between the expected and the actual profile dimension of "knowledge and comprehension" was 18.10%, that of "Application of Knowledge" was 11.36% and for "Experimental and process skills", it was 7.46%. These differences kept decreasing from 18.10% to 7.46%. This decline is an indication that, the objectives in the TESSA Lower Secondary Science OER have an inclination towards knowledge and understanding/comprehension.

This inclination was overt in the number of objectives that fell under knowledge and understanding as shown in Table 3. Out of the one hundred and twenty- six objectives counted, the number of objectives attributed to the knowledge and understanding was

48. The higher the educational ladder, the more emphasis is placed on knowledge and understanding. Examining Bruner's stages of representation, at the JHS, students are expected to operate at the symbolic stage, sometimes called the abstract stage. When using symbolic representations, pupils are no longer dependent upon the physical actions and imagery. Additionally, symbolic representations help pupils condense information into a form that fits into a given attention span (Bruner, 1960).

Since learners have the ability to learn more abstract things by acquiring and understanding knowledge, it would be easy to adapt the TESSA lower secondary OER. However, the objectives of the curriculum developers in Ghana do not seem to emphasize inculcation of more knowledge and understanding into pupils at this level. Literature has shown that learners' poor achievement in science as they move from the primary to the secondary level, could be attributed to teachers' lack of science content knowledge in the subject (Ghartey-Ampiah, 2010). Even though, TESSA aims to support teacher educators and teachers in improving teaching practices through a focus on promoting effective pedagogy, many challenges still remain (Hardman et al, 2011; Stutchbury, Acquah, Ngman-Wara, Kaulu, Shayo, Busulwa & Wambugu, 2013) trying to make it match each partner countries curriculum.

Conclusion

The study examined how the TESSA science OER reflected the profile dimensions for teaching science in Ghanaian basic schools. The findings revealed that emphasis was placed on attitudes and process skills for the TESSA Primary Science OER as designed by Ghanaian science curriculum developer. However, in the case of the TESSA Lower Secondary Science OER more emphasis was placed on knowledge and comprehension than what is expected by Ghanaian science curriculum developers. This shows that the use of the TESSA Lower Secondary Science OER will expose JHS science teachers to the needed content knowledge, which will enable them teach science effectively. This will go a long way to rectify challenges basic school science face in teaching science (Ghartey-Ampiah, 2010).

Recommendation

This study therefore recommends that regular workshops and in-service training be organized for basic school science teachers on how to use the TESSA OER to improve scientific literacy among basic school learners in Ghana. This feat would enhance learners' interest and also help them to develop a positive attitude towards studying science beyond the basic school level.

Since the methods on how scientific literacy can be acquired still lack convergence (Vieira et al, 2017), the researcher further recommends that the National Council for Curriculum and Assessment, Ghana when reviewing the basic school science curriculum could examine the TESSA science OER and adopt and adapt some of its activities, especially those on application of knowledge and attitudes/experiment and process skills it uses.

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