**Improving the Learning of Science in Secondary Schools in Kenya Using TESSA Science OERs**

**Theme: Current methods of teaching: Prospects and challenges**

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**Abstract**

*This paper reports on a project that seeks to promote effective pedagogy through interactive curriculum materials intended to enhance learners’ participation in the learning process. The project described in this paper is an extension of The Teacher Education in Sub-Saharan Africa (TESSA), which was initiated in 2005 and focused on improving the quality of primary teacher education. The current project focuses on interactive pedagogical skill for Secondary Science Teacher Education programmes. TESSA Secondary Science is funded by the Waterloo Foundation. It is a collaborative project, co-ordinated by The Open University UK with partners in Ghana, Kenya, Tanzania, Uganda and Zambia. It is designed to support the pre-service, in-service and practicing secondary science teachers. The TESSA pedagogy is anchored in the constructivist theory of learning. The TESSA OERs which are activity based focus on five themes namely; probing students’ understanding, making science practical, making science relevant and real, problem solving and creativity and dealing with challenging concepts. The OERs were developed by teacher educators from participating institutions with support from the Open University UK. TESSA OERs were contextualized to fit into respective country contexts and used to support pedagogy courses in teacher education programmes in the participating universities. Teacher educators in Egerton University have used TESSA OERs in their pre-service and in-service (school based) programmes to support pedagogy courses. Through workshops selected practicing teachers were inducted into the use of TESSA OERs. Evaluation reports reveal that TESSA OERs enable teachers to be collaborative and more innovative in developing learning recourses. The OERs have been found to be user friendly, are useful for theory and practical lessons and enhance learners’ motivation and attitude towards learning science. TESSA OERs have the capacity to enhance teachers’ creativity in improving the learning environment and actively engage learners in meaningful learning activities. The evaluation reports also reveal a number challenges that have to be overcome for effective use of the OERs.*

**Key words**; Learning of Science, TESSA Science OERs**,** Effective Pedagogy

**Introduction**

Science is an important part of a school curriculum and thereafter in the world of work. Science, technology and innovation are central to economic prosperity and to reaching the overall realization of millennium development goals (UNESCO, 2006). Being productive in Science and Technology depends on the adoption of scientific knowledge, skills and attitudes as a way of life (Semela, 2010). Development trends Worldwide show that careers in science have immensely contributed to socio-economic and Technological transformation. School science education is, therefore, crucial in laying the foundation for scientific and technological development in society.

The Millennium Development Goals recognize the importance of improving access to education and promotion of gender disparity in both primary and secondary education. However access and the quality of education especially in Sub-Saharan Africa is wanting. Securing good educational outcomes depends on effective teacher education programmes that will produce teachers with adequate pedagogical skill which in turn will improve student learning (UNDP, 2014).

The Kenyan government has developed an economic blueprint popularly known as vision 2030 (GOK, 2007). This vision aims at transforming the country into an industrialized, middle income economy by the year 2030. The vision proposes intensified application of Science Technology and Innovation (STI) to raise productivity and efficiency levels in the economic, social and political pillars. It also focuses on improving the teaching of mathematics, science and technology in schools and Higher Education Institutions (HEI). This therefore means that Science and Technology education has a crucial role to play in the realization of vision 2030. Implicit in this is an effective science education programme in both primary and secondary schools. Teachers at both levels need to be equipped with sound pedagogical skills that would enhance learners’ ability to effectively learn science and lay a firm foundation for the scientific enterprise in the country.

 Despite the important role of science in social-economic development, available data indicate that students’ performance in science in Kenya Certificate of Secondary Education (KCSE) is poor. Research has shown that poor performance in sciences is partly due to lack of sound pedagogical skills (Wambugu, Changeiywo & Ndiritu, 2013; Wachanga & Mwangi, 2004). The teaching approaches used are mainly expository in nature and make learners to be passive recipients rather than active participants in the learning process (Tsuma, 1998, Orora, Keraro & Wachanga, 2014). These teaching practices do not actively engage learners in the learning process and seem to deny them the opportunity of taking responsibility of their own learning. Effective and meaningful learning of science at secondary school level is crucial in the preparation of learners for the world of work and successful living in the modern and technological society. This therefore requires the use active learning approaches that place learners in active rather than passive roles in science lessons.

Curriculum documents worldwide make explicit reference to the use of active learning approaches in the teaching of science. Active learning is anchored in the constructivist theory of learning. The constructivist theory has its theoretical foundations on Piaget theory of ‘genetic epistemology’. According to Vygotsky, (1978); Driver and Bell (1986); Solomon (1987); Good & Brophy, (1995) the principle tenets of constructivism are, first learning is an active and social process. This therefore requires learners be actively engaged in learning in small social groups. This would engage them in negotiations of meaning of concepts and materials encountered as they actively construct new knowledge for themselves. Second, the responsibility of learning resides with the learner. This means that the learner has to choose to be actively involved in the learning process and should be willing and prepared to learn. Third, the role of a teacher is to facilitate the learning process by creating an appropriate learning environment. A teacher should plan for activities that actively engage learners and facilitate conceptual change. Fourth, learners’ prior conceptions play a significant role in the learning process. Therefore, it is a teacher’s responsibility to probe learners’ prior conceptions to facilitate the provision of appropriate learning experiences that can enhance conceptual change. This will help learners to appreciate the relevance of science to real life and enable them deal with challenging concepts. The constructivist theory guided the development of TESSA OERs based on five themes which include; probing students’ understanding, making science practical, making science relevant and real, problem solving and creativity and dealing with challenging concepts.

**The TESSA Secondary Science project in Egerton University**

 The TESSA secondary science project, that was initiated in 2010, following the success of the TESSA primary education OERs focuses on the enhancement of pedagogical skills of pre-service, in service ( School based) and practicing science teachers in secondary schools initially in five countries Sub- Saharan Africa (Uganda, Kenya, Ghana, Zambia and Tanzania). The secondary science project has been designed to address the challenges faced by teachers in the implementation of the science curriculum by improving their pedagogical approaches. TESSA Secondary Science OERs support teachers in developing learner-centered approaches to learning, and crucially, to examine their own practice (Stutchbury, 2011; Stutchbury &Katabaro, 2011). One of the projects expected outcome was to create Open Educational Resources (OERs) to support pre-service, in-service and practicing teachers in developing learner-centered pedagogical approaches to teaching science in secondary schools.

**Structure of TESSA OERs**

TESSA Secondary Science materials have five pedagogical themes. Each theme is exemplified in three contexts; biology, physics and chemistry that cover topics in lower secondary school level. These topics are common in the curricula offered in the five countries initially involved in the project. The themes and the contexts are represented in Table 1.

**Table 1**

**Themes and Contexts of the TESSA OERs for the Three Secondary Sciences**

|  |  |  |  |
| --- | --- | --- | --- |
| **Subject** **Theme**  | **Biology** | **Chemistry** | **Physics** |
| Probing students’ understanding | Classification and adaptation | Elements mixtures and compounds | States of matter |
| Making science practical | Transport | Acids bases and salts | Measurement |
| Making science relevant and real | Respiration | Combustion | Pressure |
| Problem solving and creativity | Nutrition | Periodic table | Forces |
| Dealing with difficult concepts | Cells | Particles | Electricity and magnetism |

Each of the themes starts by focusing on the learning outcomes, which are aimed at the teacher and reflects the skills and practices that need to be developed. There are three activities and three case studies with a narrative which explains the rationale behind the activities and the link to each theme. The activities are meant for a teacher to undertake and most describe things that are done in a classroom. The case studies are related to particular activities and demonstrate the pedagogical knowledge that a teacher require. Each theme has up to six resources which are meant to support teachers in developing their subject, pedagogical and content knowledge.

**Development of TESSA OERs and the Implementation Planning**

TESSA materials were collaboratively developed by teacher educators from the participating institutions in five countries in Sub-Saharan Africa. Teacher educators, in each of the respective institutions versioned the OERs to fit in their own teacher education programmes.

An induction workshop on the implementation and use of the OERs was held in Egerton University for teacher educators and practicing teachers from selected schools within Nakuru County. The action plan for the use of TESSA materials in microteaching and regular class teaching for the participants was such that they were divided in groups in their area of specialization namely physics, biology and chemistry. This helped in the understanding of what TESSA materials are and the use of the materials in the learning process. The participants worked on the pedagogical themes and agreed on how to integrate the materials in the microteaching classes for pre-service teachers and regular classes for in-service and practicing teachers. They also discussed how the in-service and practicing teachers would help colleagues in the schools/departments to use the TESSA OERs. It was important to engage in joint lesson preparation using the materials to encourage colleagues to use them. The participants were given print copies of the materials and a demonstration on how to access them from the website conducted.

**Implementation and use of the TESSA materials**

The teacher educators used the TESSA resources during microteaching and the students were expected to use them during teaching practice. Teaching practice is a core component of all pre-service teacher education programmes. Through teaching practice, a novice teacher is assumed to have inculcated a supposedly viable pedagogic experience to transfer the core competency of the subject knowledge to students in real a classroom situation. The use of TESSA materials during teaching practice was meant to enhance the pedagogical experiences of pre-service teacher. The practicing teachers were to use the resources and induct others in their schools to also use them in their science lesson. The TESSA resources targeted specific topics in the lower secondary science curriculum. Teachers were encouraged to apply the same approach to other topics in the secondary science curriculum.

**The Findings**

Monitoring of the extent and success of the use of the materials was done through interviews with the practices teachers and observation of microteaching lessons. A questionnaire was also administered on a sample of practicing teaching and pre-service teacher after their school experience (teaching practice). The practicing teachers were found to be using TESSA materials mainly during practical sessions. They were using different themes depending on the topic being covered. The use of the materials motivated learners and created positive attitudes towards science subjects

It was also realized that many schools lack materials that can be used to support teaching and classroom practices. TESSA materials were therefore, very useful, in supporting this part of the curriculum. Both pre-service and practicing teachers reported that TESSA OERs, Enhance team work among teachers in lesson preparation, and also in the sharing of resources. The OERs also enable teachers to link theory to practical experiences in the learning process. The OERs enhance teachers’ creativity and innovation developing learning resources. The materials help to minimize a teacher’s monopoly in a lesson and encourage active learner engagement in science lessons. The materials were also found to encourage learners to link everyday experiences with what is learned in science lessons. In effect therefore the materials designated a teacher’s role as a facilitator in the learning process.

The materials were found to provide an appropriate opportunity for learners to construct meanings for themselves and build on what they already knew. In addition the OERs allow learner to share and exchange ideas with each other in the learning process. Because the OERs are activity based, learners are able to develop science process skills, through active involvement in learning activities. Learners are therefore in a position to question their prior conceptions as they tackle the tasks. This facilitates as smooth transition from misconceptions to conventionally acceptable scientific conceptions. The OERs place emphasis on small group activities. This allows learners to work in mixed ability groups and thus enhance the learning weak learners as their learn from their more able colleagues and in addition it boosts their self esteem.

**Challenges of the Use of TESSA OERs**

The use of TESSA secondary science OERs presents a number of challenges to both teachers and learners. The pre-service teachers found it difficult to use TESSA OERs during their school experience because the lacked cooperating teachers who had the knowledge of TESSA OERs in their respective schools. They therefore found themselves introducing a new pedagogical skill. Many schools lack ICT infrastructure such as computers, power and internet connectivity. They therefore had to rely on the print copies of materials that were provided by the university. As a result there was limited use of the materials. In addition students cannot actively interact with the materials. Many practicing teachers in secondary school lack requisite ICT skills therefore even for those schools which have computers and internet connectivity, there is bound to limited use of the web based resources.

**Conclusion**

TESSA OERs have the potential to enhance teachers’ pedagogical skill and provide learners with an opportunity to effectively and meaningfully learn science. It is therefore recommended that teachers collaboratively develop learning materials based on active learning approaches to enhance learning of science in secondary schools. TESSA OERs provide a template that can be used to achieve this. This would improve the quality of teaching and learning of science and go along way in realizing some the millennium development goals and Kenya’s vision 2030, as Stutchbury and Ngman-Wara, (2012) put it TESSA embodies a model for change. This, indeed, should be a model of change that improves teachers’ pedagogic skills and thus the quality of education in our school.

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