Developing effective pedagogy: the thinking behind the TESSA secondary science project

Conference or Workshop Item

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Absract

The Millennium Development Goals for Africa recognise the importance of improving access to education, but the quality of the education available is also under scrutiny. Securing good educational outcomes depends on effective teacher education. Educative curriculum materials can support teachers in making the crucial link between theory and practice; between what they know and believe and what they do in the classroom. This paper reports on a project that seeks to promote effective pedagogy through educative curriculum materials intended to promote teacher learning. The materials have been developed as part of the TESSA project and have been designed to support pre-service secondary science teachers in five Sub Saharan African countries. Colleagues from five partner institutions worked together to develop a structure for the materials. The structure and the thinking behind the structure are described.

We will argue that small, incremental steps rooted in current practice are required to bring about embedded and sustainable change, and that mediation of the materials is crucial. Examples of how we seek to achieve this will be described as the TESSA Secondary Science materials become available for general use.

Introduction

Implementing change in education in Africa is both urgent and problematic. It has been suggested (SEIA, 2007) that secondary education in Sub-Saharan Africa does not contribute to human capability development as effectively as it could and that student learning and achievement remain low. This paper describes a project that is based on the premise that changes in education will come through improving teaching practices through a focus on promoting effective pedagogy (Hardman et al, 2011), and that change is more likely to be successful if it takes place with closest proximity to the problem (Elmore, 1979). This is significant because too often the focus is on 'what shall we teach?' rather than 'how shall we teach?', New Governments coming to power, often wish to improve the education system and immediately set up a review of the curriculum. Evidence suggests, however, that it is the 'how' that is likely to make a difference (Hardman et al, 2011; Leach and Moon,

2008). The focus of this project is on teaching science, in the lower secondary school, which is appropriate as strong performance in maths and science is associated with economic growth.

The project described here is an extension of 'Teacher Education in Sub-Saharan Africa' (TESSA), which ran from 2005-2010 and focussed on improving primary education. A resource bank, including of 75 units of work, rooted in the primary curriculum, and versioned for different countries, has been made available as Open Educational Resources (OER). In 2010, funds were secured (from The Waterloo Foundation) for TESSA Secondary Science, which will extend the TESSA approach to lower secondary level in five countries – Ghana, Kenya, Tanzania, Uganda and Zambia. This paper describes the thinking behind TESSA Secondary Science and argues that whilst it is impossible to cover the whole of the secondary curriculum in five different countries, resources in the form of OERs, it is possible to identify a range of appropriate pedagogies that can be adapted for different contexts. In the process of doing the adaptation, teachers will better understand new pedagogies, and will be encouraged to enact them in their classrooms. The project has been shaped by the context in which we are working, learning from the TESSA project and a firm belief that improvements in pedagogy will deliver improvements in educational outcomes.

Evidence from the TESSA project suggests that the resources developed are making a difference in many primary schools (TESSA Case studies, 2010). TESSA Secondary Science is therefore based on the same key principles, with the details being adapted for the different context. We will begin therefore by articulating those principles, describing the context and explaining how the difference between the primary and secondary contexts have influenced the way in which the project has developed.

Introducing TESSA Secondary Science

The TESSA Approach

There are five important principles that underpin the TESSA approach to affecting educational change:

- Educational outcomes could most effectively be improved by improving the quality of teaching.

- To be sustainable, the resources used to improve teaching need to be developed in Africa by Africans.
- The most effective way to produce high-quality materials that will be widely used is through collaboration.
- The materials must be freely available, with the ability to be adapted for individual use. (TESSA, 2008)
- The materials are be versioned for use in different countries. In this way the resources 'speak' to teachers more effectively and the process of versioning provides an opportunity for teams within the partner institutions to become involved in the project.

Furthermore, TESSA embodies a model for change advocated by Richard Elmore (1979) in which the invention takes place at the point at which the change is needed i.e in the classroom. Elmore argues that solving problems in complex systems involves maximising discretion at the point where the problem is most immediate and 'the closer one is to the problem the greater is one's ability to influence it' (Elmore, 1980, 605). Formal organisational structures with a high degree of hierarchal control are not necessarily helpful and the more steps that are required for implementation, the less likely that a policy will be successful. For this reason the objects of the TESSA approach are teachers and teacher educators, rather than policy makers and district officials. The template for the TESSA units is described in box 1.

The TESSA Template

All TESSA units contain the following components:

- Learning outcomes for the teacher. These are statements, which describe what the teacher will learn to do as a result of running the activities described in the unit, in their classroom.
- Three activities that the teacher could carry out in their classroom.
- Three case studies that show how the activity, or a similar one might run, taking into account contextual factors such as large classes, and few resources.
- Resources to support the teacher in running the activities and understanding

the pedagogical strategies being introduced.

- A narrative, which explains to the teacher the benefits of the approaches that are being promoted.

The secondary context

Secondary schools in Sub-Saharan Africa are under considerable pressure at present (Verspoor, 2008), with shortages of space, equipment and teachers. This is because there have been considerable advances towards the achievement of Millenium Goal 2: universal primary education by 2015 (UNDP, 2011). Countries in Sub-Saharan Africa (SSA) that previously educated around 50% of primary aged children are now achieving 70-80%. There is therefore an urgent need for the expansion of secondary education with more schools, resources and teachers, and a focus on quality, particularly in science and mathematics. Many primary school teachers have very little formal training and in many countries there is therefore a culture of in-service development with teachers working towards certificates and diplomas. TESSA resources are being used in a variety of ways on many such programmes (Thakrar et al, 2008). In the secondary sector, however, there are well-established pre-service programmes. Secondary teacher training takes four years and involves subject knowledge development and pedagogic preparation, with these often being conducted in different faculties within an institution. Collins and Gillies (2008) believe that the structure of the current system for training teachers will not allow for the necessary expansion. Criticisms of the programmes (Verspoor, 2008) include:

- an over-emphasis on theoretical studies which are not explicitly linked to practice;
- insufficient supervision and mentoring;
- the tendency of pre-service teachers to teach as they themselves were taught.

Collins and Gillies (2008) suggest that pre-service training needs to be accelerated with shorter periods of pre-service education and a greater emphasis on in-service training. They believe that pre-service programmes need to be re-designed with a

greater emphasis on the practical application of the theory. It is in these circumstances that educative resources that support student teachers and teachers in developing effective pedagogy could make a difference, and it is likely that there will be a growth in in-service training.

Given the fact that nearly all secondary school teachers follow a pre-service course, which includes a period of school experience, it was decided to target student teachers and teacher educators in the production of the TESSA Secondary Science units, whilst being aware that they would also find an audience on in-service courses.

TESSA Secondary Science

It was decided that TESSA Secondary Science should follow the same principles and use the same template as the original TESSA project. Funds were secured to develop a total of 15 units. The pressure of external examinations and overloading of the curriculum, mean that the activities are often very short. This is important, as it became clear during the initial workshops that teachers were unlikely to engage with anything that they perceived would stop them completing the syllabus. The activities often involve 'standard' experiments for exactly the same reason, but we have tried to build into the units a flavour of some of the 'big issues' facing the continent, in order to encourage secondary school students to engage with the debates. The units are constructed around five pedagogical themes.

Pedagogical themes and contexts

Defining pedagogy in a short sentence is very difficult; it embraces the skills of an individual teacher, the ways in which they present material, and their mode of engagement with social processes. Good teachers see pedagogy as a dynamic process, manifested in the daily interactions between teachers and learners. They are curious about pedagogy and are reflective and evaluative about what they do. Crucially, pedagogy is informed by theories and beliefs (Leach and Moon, 2008). The starting point therefore for a project to develop and support effective pedagogy was the explicit articulation of the values and beliefs shared by the group.

Representatives from each of the five partner institutions gathered in Tanzania and the first morning was spent considering the question: what makes an effective

secondary science teacher? Colleagues worked in pairs to identify the skills, knowledge, practices and attributes displayed by an effective teacher. A discussion followed in which the ideas were captured; no idea was recorded that wasn't completely understood and agreed by everyone. The result was a description of an effective teacher (appendix 1), which embodies the values and beliefs of the group. The next challenge was to convert this into a set of pedagogical themes that would be highlighted in the materials. After much discussion and debate, drawing on the collective experience of teachers and teacher educators from five African countries and the UK, five themes were identified and agreed. The themes were cross-checked against the definition of an 'effective teacher' and the group were satisfied that in writing resources based on the five pedagogical themes, they would be supporting teachers in learning to become more effective (table 1).

Pedagogical theme
Probing students' understanding
Making Science practical
Making science relevant to everyday life
Problem solving and creativity
Dealing with challenging ideas

Table 1: Pedagogical themes exemplified in TESSA Secondary Science

The themes therefore emerged from the collective professional experience and knowledge of teachers and teacher educators from five different countries. It is interesting to note that using a completely different approach, a group of researchers in the USA came to a broadly similar conclusion.

Davis and Krajcik (2005) describe a project to produce 'educative curriculum materials' for use in secondary science teacher education in the USA. They describe a set of nine 'design heuristics', based on what they consider to be the important parts of a teacher's knowledge base: subject knowledge, pedagogical content knowledge for specific topics and pedagogical content knowledge for disciplinary practices. The heuristics are based on the challenges that teachers face as identified through a review of the literature. The 'themes' underpinning the TESSA Secondary Science project are based on the collective experiences of teacher educators from five

African countries and the UK, and our agreed vision of an effective secondary science teacher. Interestingly there is considerable overlap (see table 2), which gives support to both the TESSA approach and the framework that presented by Davis and Krajcik.

Table 2: A comparison of the design heuristics for educative curriculum materials as identified from the literature (Davis and Krajcik, 2005) and the TESSA Secondary science themes.

Themes of TESSA Secondary Science	Design Heuristics
Science lived – making science relevant to the everyday	Supporting teachers in engaging students with topic-specific scientific phenomena
Probing childrens' understanding	Supporting teachers in anticipating, understanding and dealing with children's ideas about science
	Supporting teachers in engaging students in questions
Making Science practical	Supporting teachers in engaging students with collecting and analysing data
	Supporting teachers in engaging students with designing investigations
Dealing with challenging ideas in science	Supporting teachers in engaging students in making explanations based on evidence
	Supporting teachers in using scientific instructional representations
These feature across all the themes through the resources that accompany each TESSA unit.	Supporting teachers in promoting scientific communication
	Supporting teachers in the development of scientific knowledge

The theme identified in TESSA secondary science that does not seem to represented in the 'design heuristics' for educative curriculum materials is 'problem-solving and creativity'. This theme 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 were skills and attributes that should be fostered in pupils through the curriculum. The three units within this theme will support the teacher in being creative and resourceful whilst developing these skills for their pupils. A possible explanation for the absence of this theme from a review based on the literature is that a clearer identification of the nature of science and what children should learn about it, has taken place in recent years (Osbourne et al, 2003; Bartholemew et al, 2004), which sees working scientifically as more than doing experiments. It is possible that Davis and Krajcik might include a heuristic based on promoting creativity if they were to revisit this work today.

There is further support in the literature for the pedagogical themes that we have identified. Grossman *et al* (2009) argue that teacher education should be organised around a set of core practices based on pedagogies of enactment. In their model for teacher education, knowledge, skill and professional identity would be developed in the process of learning to practice. They suggest some 'core practices', which include *eliciting student thinking.* Their ideas on re-structuring teacher education courses are developed in the USA but are perhaps even more pertinent in the African context, where traditionally theory and practice are treated separately.

Thus the pedagogical themes identified through the process described provide a credible structure for the resources. They are exemplified in a number of different scientific contexts.

Scientific contexts

It was clear at the planning stage that we did not have sufficient resource to cover the whole of the lower secondary science curriculum and decisions would need to be made as to which contexts were used to exemplify the themes. Some preliminary work was done to identify topics that are taught in all five countries in the lower secondary curriculum. These topics were presented to the group and they were asked to use their knowledge of schools in their country, the science curriculum and

the topics that student teachers find harder to teach, to select a topic for each theme. It quickly became clear that it would be most appropriate to choose topics that could clearly be identified as 'physics', 'chemistry' or 'biology'. Thus, titles for 15 units were chosen, enabling each theme to be exemplified in physics, chemistry and biology (table 3).

Theme	Biology context	Chemistry context	Physics context
Probing children's' understanding / learning	Classification and adaptation	Elements, compounds and mixtures	Mechanics & properties of matter
Making science practical	Transport	Acids, bases, salts	Measurement
Science lived (relevant and real)	Respiration	Combustion	Pressure
Problem solving – creativity – innovation in science	Nutrition	Chemical families & Periodic Table	Forces
Dealing with challenging ideas in science	Cells	States of matter	Electricity and magnetism

We would argue that we are aiming to affect change by establishing a particular way of thinking about learning and teaching. Once this way of thinking has been understood and embraced, the activities described in the units, can, with the help of the case studies, be adapted for different contexts.

Affecting change

The approach to learning and teaching that is embodied in the collective vision of an effective science teacher, is one which is learner-centred, in which students construct knowledge as a result of engaging in and discussing, different activities. The role of the teacher is to enable the learners to construct knowledge, to understand and engage with their ideas and to provide opportunities for students to work together to extend and develop their knowledge. All the participants in the exercise were committed – as many teachers are - to learner-centred approaches. However, enacting these approaches is often more difficult that it seems. Brodie et al (2000) refer to the 'form' and the 'substance' of learner-centred teaching and

their ideas have influenced this project. They argue that embracing the 'form' of learner-centred teaching is relatively straightforward; it involves for example, thinking about how resources are used, using group work, thinking carefully about the nature of the tasks being set and the careful use of questioning. Embracing the 'substance' involves understanding and engaging with students' ideas and enabling learners to develop new knowledge. Not surprisingly perhaps they found in a project conducted over three years, that w an encouraging number of teachers embraced the 'form' of learner-centred approaches, but relatively few embraced the substance. They also found that none of the teachers in the study embraced the 'substance' without the 'form'.

This has implications for the implementation of TESSA Secondary Science and emphasises the challenge of establishing new ways of thinking. We are reconciled to the fact that it will take time to embed this way of thinking in the institutions in which we are working but it is worth highlighting three principles that have emerged during the project and from the literature that will drive the implementation phase. Firstly, we are convinced of the importance and value of modelling the activities (Ref). Student teachers are unlikely to have been taught in this way, and by working with teacher educators who are in a position to model the activities in their own teaching, we are creating the opportunity for student teachers to experience learner-centred teaching . Secondly, We are mindful of the link between the 'form' and the 'substance'. The activities in the TESSA secondary science units support teachers in making small, and therefore manageable changes in their practice. Experience in TESSA primary shows that as teachers build confidence, they are prepared to take risks, but getting to that stage is a gradual process. Finally, the idea that new knowledge is socially constructed is particularly pertinent in this context. Student teachers and teachers will benefit greatly from working together to adapt activities and evaluate their own experiences. The growth of the OER movement is particularly helpful in this respect (ref) as by engaging with the TESSA Secondary Science units and adapting them to new contexts, student teacher and teachers will really begin to change their thinking.

Conclusion

Affecting change in the secondary context presents many challenges, not least the size of the curriculum, the pressures created by the examination system and entrenched attitudes about what is and is not possible. However, whilst educational outcomes remain poor, it is an argument that we must continue to make, and the barriers to change must be addressed. The TESSA Secondary Science resources are based on a strong rationale and include activities and case studies that support effective teaching and learning. They are based on a model of change that has been proved to be effective in the primary context. Encouraging teachers and student teachers to adapt the activities to different contexts will be crucial as through that process the ideas and practices promoted in the units will be understood and developed.

References

Brodie, K., Lelliott, A., Davis, H., (2002) Forms and Substance in learner-centred teaching: teachers take-up from an in-service programme in South Africa. *Teaching and Teacher Education,* 18, 541-559.

Collins, P. and Gillies, J., (2008) The expansion of Secondary Education and the need for teachers: how big is the gap? USAID Education Quality Improvement Programme. (EQUIP2)

Davis, E., Krajcik, S. (2005) Designing educative materials to promote teacher learning. Education Researcher.34, 3, 3-14.

Elmore, R.F., (1980) Backward mapping: Implementation research and Policy Decisions Political Science Quarterly, Vol 94, No. 4, 601-616.

Grossman, Pam , Hammerness, Karen and McDonald, Morva (2009) 'Redefining teaching, re-imagining teacher education', Teachers and Teaching, 15: 2, 273 — 289

Hardman, F., Ackers, J., Abrishamian, N., O'Sullivan, M. (2011) Developing a systematic approach to teacher education in sub-Saharan Africa: emerging lessons from Kenya, Tanzania and Uganda. Compare 41, 5, 669-683

Leach, J., Moon, R. (2008) The Power of Pedagogy. London: Sage

Osborne, J. , Collins, S. Ratcliffe, M., Millar,R., Duschl, R. (2003) What "Ideas-about-Science" Should Be Taught in School Science?A Delphi Study of the Expert Community *JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 40, NO. 7, PP. 692–720*

SEIA, 2007, At the crossroads: choices for secondary education in Sub-Saharan Africa. SEIA synthesis report. Downloaded from :

http://siteresources.worldbank.org/INTAFRREGTOPSEIA/Resources/Executive_Summary.pdf Jan 28th 2011.

TESSA (2008) www.tessafrica.net

TESSA (2010) Case studies produced by participating institutions as part of the TESSA evaluation project. Unpublished.

Thakrar, J., Zinn, D., Wolfenden, F. (2009) Harnessing Open Educational Resources to the Challenges of Teacher Education in Sub-Saharan Africa. *International Review of Research in Open and Distance Learning* 10, 4, 1-15.

UNDP (2011)

Verspoor, A. (2008) At the crossroads: choices for secondary education in Sub Saharan Africa. Washington: World Bank.