# Implementing TESSA 'Teaching Lower Secondary Science': initial trials and the implications for partnership working.

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## Abstract

Teacher education in Africa has been criticised for being not 'fit for purpose' (Verspoor, 2008, Mulkeen, 2010). The TESSA programme was established in 2005 to support teacher education at primary level, and there is evidence that the initial project has made an impact across Sub-Saharan Africa (Harley et al., 2012). This paper describes the TESSA Teaching Lower Secondary Science project, which extends the TESSA approach to secondary schools. Colleagues from five countries worked together to produce 15 units of work to support teacher education. The units are grouped around five pedagogical themes and aim to address some of the challenges faced by secondary teachers. They are based on the belief that student-centred approaches to learning produce the best results and that discussions about how to teach are more productive that discussions about what to teach. The units are now being trialled in the partner institutions and this paper describes some of the activities that have been taking place. Initial impressions are encouraging, but there is much still to be done. We conclude with a review of some of the criticisms of secondary teacher education in Africa and demonstrate how, with carefully planned interventions, the TESSA secondary science resources could begin to address some of these problems, particularly in the field of partnership working.

## Introduction

The TESSA programme (2005- present) is based on the premise that improving the quality of teaching is key to changes in education across Africa. It aims to support teacher educators and teachers in improving teaching practices through a focus on promoting effective pedagogy (Hardman et al, 2011). It is underpinned by the belief that the change is more likely to be successful if it takes place with closest proximity to the problem (Elmore, 1979) – that is, in classrooms, involving teachers and their students. In TESSA, the education of primary school teachers is supported through a resource bank which includes 75 units of work, rooted in the primary curriculum, versioned for different counties and made available as Open Educational Resources. The resources are designed to make explicit links between theory and practice, encouraging teachers to adopt child-centred approaches to teaching and learning. There is current evidence of success (Harley et al., 2012), but many challenges still remain and work continues with partner institutions in order to extend and embed TESSA at all levels within the education system.

In 2010, funds were secured from the Waterloo Foundation to extend the TESSA approach to Science at lower secondary level, in five countries – Ghana, Zambia, Kenya, Uganda and Tanzania. Unlike their primary counterparts, many secondary school teachers undergo formal training, although at lower secondary level this is not always the case. However, even when teachers have undergone training, courses in Africa at all levels have been criticised (Verspoor, 2008):

- there is an over-emphasis on theoretical studies which are not explicitly linked to practice;
- there is a tendency for pre-service teachers to teach as they themselves were taught;
- there is insufficient supervision and mentoring, and weak partnerships with schools.

These problems are particularly acute at secondary level: courses often take up to four year yet only include a few weeks in school and the content is highly theoretical with subject and pedagogy being taught separately, often in different departments. There is also a mis-match between what is being taught in the universities and the practice that pre-service teachers encounter in schools. They often have a good understanding of the advantages of constructivist approaches to learning, for example, but do not see these approaches being implemented in schools. There is a tendency therefore, to quickly revert to teaching in the way in which they themselves were taught.
The expansion in primary education in recent years has also led to a crisis in the secondary sector: more children are looking for places at secondary school and there is shortage of teachers and school places in some countries. Increasingly primary school and unqualified teachers find themselves working in secondary schools.

This paper explains the thinking behind the TESSA Teaching Lower Secondary Science project and the resources that have been produced. It describes the ways in which the resources are being used in the partner institutions and reports on initial evaluations of the project, in the context of the challenges facing teacher educators. Finally, we will discuss the way forward. One of the features of high quality teacher educator programmes is strong partnerships between schools and Higher Education Institutions, and we believe that the TESSA Teaching Lower Secondary Science resources have the potential to provide a basis for such partnerships.

## The TESSA approach

The TESSA project is underpinned by five important principles:

- Improving the quality of teaching is key to improving educational outcomes;
- To be sustainable, resources 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 and institutional use;

- The materials are versioned for use in different countries. In this way the resources 'speak' to teachers and the process of versioning is part of the education and development process.

The project is underpinned by the belief that active approaches to learning are likely to produce better outcomes for students than teacher-led lessons in which students are passive participants, and that it is the role of the teacher to support students in constructing understanding, taking into account prior knowledge and experience. Teachers are also considered to be 'learners' and teacher learning is conceptualised within the TESSA community as:

*'.. being social, jointly constructed with pupils and peers; distributed, shared over the people, activities and artefacts within the environment; and situated, linked to the circumstances in which it occurs, the particular working practices and their associated ways of thinking'.* (Wolfenden, 2008, p9).

The objects of the TESSA approach are teachers and teacher educators, and the development of strong partnerships between participating institutions and schools, is at the heart of the project. The original primary units that have been produced are all based on a template which includes: learning outcomes for the teacher, three activities to carry out in the classroom, three case studies which exemplify how the activities might work, resources to support the teacher in running the activities and a narrative which explains to the teacher the benefits of the approaches that they are being encouraged to adopt. The same template was used in the TESSA Teaching Lower Secondary Science project, but the different context has led to a few significant differences.

## The secondary context

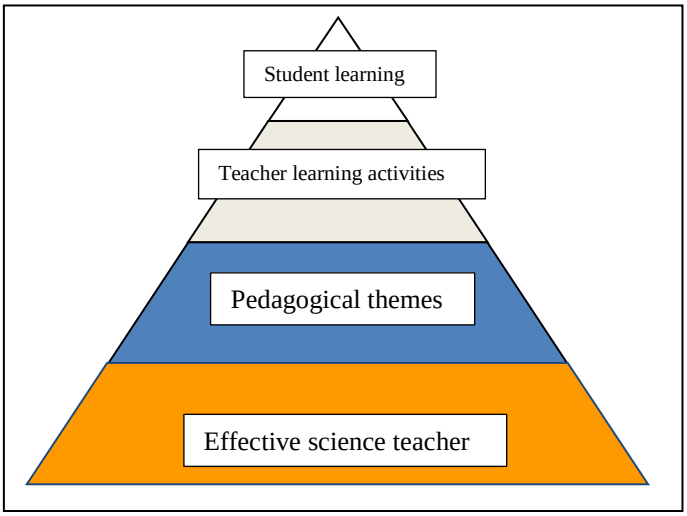
The TESSA primary resources have been available for about five years and many people are familiar with the resources and the approach. It is therefore worth highlighting some of the differences between the secondary science resources and the primary resources.
Firstly, it was decided to organise the resources around a set of pedagogical themes. We worked as a group (one or two representatives from each of six partner institutions) to agree a definition of an 'effective science teacher'. This definition was used to identify five pedagogical themes, around which the resources should be organised.
Secondly, it was decided not to try and cover the whole of the science curriculum. Across five different countries, this would be an enormous task. Instead by comparing the science curriculum at lower secondary level across the five countries involved, we were able to highlight common science topics. Each theme was exemplified in physics, chemistry and biology, giving a total of 15 units of work.
The themes and the chosen topics are presented in table 1.The approach is summarised in figure 1.

**Table 1**
***Themes and topics***

| Theme | Physics | Chemistry | Biology |
|---|---|---|---|
| **Probing students' understanding** | States of matter | Elements, mixtures and compounds | Classification and adaptation |
| **Making Science Practical** | Measurement | Acids, bases and Salts | Transport |
| **Making science relevant and real** | Pressure | Combustion | Respiration |
| **Problem solving and creativity** | Forces | Periodic table | Nutrition |
| **Dealing with challenging ideas** | Electricity and magnetism | Particles | Cells |

**Figure 1**

TESSA Secondary Science builds on the notion of an 'effective science teacher' (as agreed by the group) to improve student learning.




During the course of the project, our partners identified particular challenges that they face at secondary level and these have shaped the way in which the project developed.

| Challenge | Effect on the resources |
|---|---|
| Examination pressures. Secondary science teachers are under pressure owing to the crowded curriculum. Teachers would not have time to undertake activities that were different or extra to their normal teaching. | The activities suggested are often very short. They make use of homework time, or may be as simple as encouraging the teacher to make the classroom more interesting by displaying students' work. They draw on common and popular activities that teachers are likely to be doing. The link to the examinations is made explicit, but the activities are still student-centred. |
| Difficulty. Science is perceived to be a hard, boring subject. When students have the opportunity to make choices, the | The resources are promoting a way of learning that will lead to improved attitudes. There is a strong emphasis on |

| | |
|---|---|
| numbers opting for science subjects are low. | making links between scientific ideas and everyday life. As well as covering the curriculum, the resources introduce some of the big issues facing the continent that we hope will motivate young people. |
| Girls and science. A number of colleagues report that very few girls choose to study science. | The case studies and activities have been carefully checked to make sure that girls and boys are equally represented and that there is a balance of activities likely to appeal to boys and girls. The narrative also supports the teacher by suggesting strategies to make sure that girls take a full and active part in the lessons. |
| Language problems. This was highlighted as a particular problem in Tanzania, where the language used in Primary schools is Swahili. Students in the lower secondary school are being taught in English for the first time, and in science, with a considerable amount of specialist vocabulary, this is a problem. | This issue was raised during the versioning process and specific literacy activities have been included so that teachers have strategies for supporting students with their language in the science classroom. |
| An inadequate supply of teaching and learning materials. This was raised by colleagues in Ghana where the expansion of primary education has created a shortage of secondary school places and a shortage of secondary teachers. Primary school teachers are increasingly being asked to teach at secondary level, and need resources to help them. | The resources are all available as OERs and include pedagogical and subject knowledge support for the teacher. |
| Qualified teachers. At primary level, a greater proportion of the teachers are untrained. In many places they use the TESSA resources as part of their certificate and diploma courses. At secondary level, many teachers are trained and are familiar with ideas such as constructivism and student-centred approaches. However, they are also very quick to explain why they can't adopt these approaches in their classroom owing to large classes, a lack of resources and pressure of examinations. It is possible that pre-service teachers coming into schools, will be discouraged from trying these approaches. | It is hoped that the resources will be used by pre-service teachers (as well as teachers and teacher educators). As they learn the background theory, the resources will help them to understand how to put the ideas into practice. Also, issues such as large classes and a lack of resources are explicitly tackled through the case studies which illustrate how other teachers have managed to implement child-centred learning, despite the difficulties.<br>By encouraging pre-service teachers to develop support networks between themselves, and involving school teachers in workshops in the universities, it is hoped that some of the difficulties will be overcome. |

The selective coverage of the curriculum represents both a challenge and an opportunity. There is a real danger that a student teacher looking for inspiration will be focussed on the topic that they have to teach and if TESSA Teaching Lower Secondary Science does not happen to address that topic, then they will move on. However, the clear identification and explanation of the pedagogical themes, means that it is not too difficult for teachers to devise their own activities for new topics, based on the themes presented. In fact, working with a group of colleagues to devise new activities provides a very powerful learning experience for both student teachers and experienced teachers. The evidence from the TESSA Evaluation (Harley et al., 2012) is that the resources work most effectively when they are mediated and discussed by teachers, before they are used. This was confirmed in some preliminary work that we did around implementation at one of the project workshops. All the participants took part in semi-structured interviews, designed to help us understand their motivations and pressures that they face. As a result of this work (Stutchbury, 2011), we identified some key challenges:

- Supporting teacher educators in embracing the substance of learner-centred approaches and modelling these approaches in their own teaching.
- Developing the capacity of pre-service teachers to implement student-centred approaches to teaching, rather than to teach in the way in which they were taught.
- Ensuring that pre-service teachers are supported when they are in school.
- Making sure that the resources support the curriculum in a way that means they are used and not seen as a distraction from the matter in hand – preparation for examinations.

This suggested that implementation needed to involve teachers and teacher educators. Much of the teaching that takes place in colleges of education is in the form of formal lectures; we realised that teacher educators need to be supported in modelling the approaches that they are trying to promote. If this is successful then pre-service teachers will go into school equipped with the knowledge of how to put into practice the theories and concepts that they have learnt. They will not only have read and heard about student-centred approaches to learning, but will have experienced the approach themselves. The support that pre-service teachers receive in school will also be important and for that reason, some of the partner institutions have involved local teachers in their implementation activities.

## Case Studies

The different partner institutions have trialled the units in different ways. Egerton University in Kenya have been actively involved with the original TESSA primary project and subsequent projects to embed the resources and the approach in their institution. They therefore adopted a model for trialling that has been used before and involves teacher educators and teachers, working together to understand the resources and to plan for their use. Dar es Salaam University of Education (DUCE) are a new TESSA partner. Their representative on the project works in the university secondary school, which is located on the university campus. He already has a reputation in Tanzania as a National coordinator of in-service training and has incorporated the TESSA secondary science resources into his work. In Uganda, Ghana and Zambia,

the project representatives were new to the TESSA approach. They have trialled the resources within their own institutions and have investigated their initial impact through interviews, focus groups and questionnaires.
These different approaches to implementation and evaluation reflect the TESSA philosophy: colleagues are encouraged to do what is most appropriate in their particular context to ensure that the resources make an impact. We will now describe the activities in more detail and present a preliminary assessment of how the units have been received.

## *Kenya*

In Kenya, the TESSA teaching Lower Secondary Science team organised a workshop involving 18 teachers and 7 teacher educators. The objectives of the workshop were:

- To bring together teacher educators and practicing teachers
- To understand the TESSA approach
- To plan for the use of the TESSA Secondary Science materials.

Teachers and teacher educators worked together in subject groups. Each group identified one theme to develop and worked out how to integrate the unit into micro-teaching and teaching. The group made a plan for sharing their ideas within their institutions and made arrangements to observe each other teaching. The project is still in the early stages, but preliminary results indicate that the materials were helpful during the micro-teaching for teacher educators when preparing student teachers for teaching practice. The practicing teachers found the materials useful in making science interesting and learners found it easier to understand abstract concepts. The team are confident that the TESSA materials will promote a way of learning that will develop positive attitude towards secondary school science, thus improving the achievement. However, a significant outcome of the workshop was the opportunity for teacher educators and teachers to work together to build trust and understanding. It is hoped that when the pre-service teachers start their teaching practice in these schools, they will be better supported, as the teachers will be keen to work with them to use TESSA secondary science materials.

## *Tanzania*

TESSA participated in the Saba Saba Exhibition of 2012. During the exhibition, both the President of the United Republic of Tanzania Dr. Jakaya Mrisho Kikwete and the Prime Minister Hon. Mizengo Pinda visited TESSA exhibition site and they recommended the teaching and learning resources developed by TESSA to be uploaded in the Tanzania Beyond Tomorrow (TBT) Website and that the initiative has to be extended to cover all secondary science curriculum in Tanzania. The process is on the way to implement this request.

There is a tradition in Tanzania of the ‘casade’ model for in-service training, with national co-ordinators training regional co-ordinators, who then go out to regional teachers’ centres and train teachers. One of the national co-ordinators is a member of the TESSA secondary science team and has been using the resources in his work with science teachers.

So far specific activities include:

- Student teachers at Dar es Salaam College of Education have been using the resources in some of their college assignments. They will be working in schools between July and September 2013, where they will be expected to try out the lessons that they planned for the assignments.
- Work has been done with 7 Colleges of Teacher Education in Tanzania. The units are increasingly being used to support micro-teaching and in one college, the resources have been made available through the college website. Tutors are also using them to support their own teaching.
- National and regional co-ordinators have been using the resources in their work with teachers all over the country. Teachers have been positive about the materials and the reasons they give are:
    - The materials will minimize time of their lesson preparation
    - The resources mentioned are available in the school environment
    - The case studies give alternative approaches to the teaching of the subject
    - There is a lack of text books in many schools, so the materials will minimize the problem of books.

The main issue in Tanzania is the availability of stable internet connections and a lack of skill in the use of computers for some teachers. Where they have access and the necessary skills, teachers are adapting the materials, but this is not yet widespread.

Thus, in Tanzania, there is an ambitious programme to disseminate the resources. At this stage, the positive response that they have received is encouraging, but we are looking for evidence that this initial enthusiasm is sustained.

## *Zambia*

In Zambia, it was decided to involve four university science educators, five experienced female teachers in secondary schools (all of whom participated in the versioning of TESSA science materials last year) and 3rd and 4th year university students who are pursuing a BSc/Ed Programme.

Teachers in schools used TESSA science materials in their lessons. They tested their students on their knowledge of science before and after they had used the TESSA resources. Both the teachers and the students also responded to a questionnaire. The pre-service teachers based in the university used the TESSA resources in planning micro-teaching exercises and also completed a questionnaire.

The preliminary results are encouraging, with teachers, pre-service teachers and school students reporting that

- the TESSA approach made the lesson more enjoyable;
- they felt more motivated to teach or learn science;
- the resources helped to promote understanding of difficult concepts.

School students also reported that

- they enjoyed the opportunity to be creative and to discuss the science with their friends;
- they liked doing more practical work;
- they liked being able to work at their own rate.

Pre-service teachers also reported that

- the resources are easy to use;
- some of them covered more science in the lesson then by traditional methods;
- the resources helped them to be more creative in their teaching and gave them more flexibility than traditional methods.

Teachers also reported that

- they covered more science in the TESSA lessons that they normally did;
- the students understood the concepts better;
- the resources helped them to be creative and to improvise.

Initial results from the test that students were given suggest that resources had a good effect on learning, but more work, over a longer period of time is needed before this sort of impact can be claimed.

## *Ghana*

At the University of Education, Winneba, colleagues investigated the use of the TESSA resources with a group of pre-service teachers. The case study investigated pre-service teachers' reflections on the use of TESSA secondary science resources during a semester internship programme. The sample consisted of 34 (8 females and 26 males) fourth year Basic Education students. During preparation of the internship programme, they were taken though the TESSA resources after which they used them to prepare lessons for micro teaching seminars and also during their one semester internship in basic schools. Questionnaire and focus group discussions were used to collect data. Again, the response was positive and the pre-service teachers highlighted the following:

- The resources are motivating. Several of the pre-service teachers felt more highly motivated to teach science and believed that their students would develop a more positive attitude to science if taught in this way.
- The resources support practical work, but all the materials suggested are readily available in the local community. This means that practical work becomes much less daunting for the teacher as they are not being directed towards specialist equipment that is unlikely to be available.
- The resources did not just tell them what to do, but how to do it and why it was important. A number of the pre-service teachers commented on how the text-books do not provide this sort of support for the teacher.
- The students worked harder during the lessons. '*Most of the work I do is done prior to lesson presentation and it involves preparation for the lesson. During the lesson presentation, all I do is serve as a guide. Students do all the work and present their findings'.*

Considerable challenges remain, however, and the pre-service teachers identified the lack of computer access in school and the need for the teachers they would be working with to understand the approach as particular issues that need attention. They would also like to see more textbooks which included guidance on how to teach as well as what to teach.

### *Uganda*

Versioning in Uganda was combined with demonstrating the units and the approach to colleagues across the Faculty. The purpose was to emphasise that although the pedagogical themes are exemplified in Physics, Chemistry and Biology, the approach extends easily to other science topics, and indeed to other subjects such as computing and mathematics. It was then decided to focus efforts on the recent alumni of the university, now working in local schools, and plans were made to invite 30 teachers to a workshop to learn about the resources and how to use them.
Colleagues in Makerere University are keen to emphasise the potential for science education to produce better citizens, more knowledgeable about health, the importance of using natural resources carefully and the impact of human activity on the environment. Urgent reform of the school curriculum is required in Uganda, but in the meantime the TESSA science resources are being used to model student-centred approaches on teacher education programmes, and to encourage teachers to relate scientific content to the lives of their students.

### *Conclusions*

Overall the reception of TESSA secondary science has been positive. However, trialling is still taking place and it is too early to assess the real impact. Much will depend on the initial interest and enthusiasm being maintained, so that the approaches that are explained in the resources become embedded in teacher education programmes. However, there is much to be encouraged about at this stage, in particular the acknowledgement that the resources draw on materials that are readily available in order to promote practical work, and that pre-service teachers appreciate the guidance provided by the case studies. It is encouraging that some people have reported that they felt that they taught more science during a TESSA lesson, as one of the most common responses to the question of why student-centred approaches are not being used as much as we would hope is that ‘we don’t have time. It is also encouraging that some secondary teachers have commented on the fact that they recognise the activities as things that they would be doing in their normal teaching and can see the relevance of the activities to the examinations.

## Discussion

We explained at the beginning that the TESSA project was conceived to address some of the criticisms surrounding teacher education programmes. At secondary level, three particular aspects were highlighted (Verspoor, 2008):

- courses are too theoretical with insufficient focus on subject pedagogy and insufficient time in school;
- there is insufficient modelling on teacher education programmes of the approaches that teacher educators are trying to promote.
- partnerships between schools and universities are weak, with the result that when pre-service teachers are in school, they are not well supported;

During a short space of time, we have evidence that the TESSA lower secondary science resources have the potential to address some of these issues.

The Ghana and Zambia case studies demonstrate how pre-service teachers can begin to recognise and appreciate the explicit guidance contained in the resources about how to teach. In some universities, 'teaching methods' courses are based in the Department of Education, whilst the subject matter is taught in the Department of Science. There is a danger that specific subject pedagogy does not get sufficient attention and newly qualified teachers are left with a good understanding of educational theory, but do not fully understand how to put it into practice. The fact that pre-service teachers are using the materials to support micro-teaching and written assignments is encouraging, and the explicit linking of theory and practice that runs through the materials, begins to address the concern that courses are often seen as being too theoretical.

During the implementation workshop held in Ghana in 2012, and the versioning workshops held in individual countries, the importance of modelling student-centred approaches was emphasised. For example, when asked what he was going to do with his students next week, a young Ugandan teacher who had taken part in the versioning workshop explained how he was going to take his students (pre-service teachers) into the university grounds where there is a large pond. They were going to identify the creatures they could find and discuss the food chain in that habitat - he had clearly understood the message. Evidence from the writing workshops is that teacher educators regarded their involvement in the project as an opportunity to learn themselves, and have changed their practice as a result of their involvement in the project. Modelling remains a challenge however, and TESSA partners have a lot of work to do within their institutions to embed these sorts of practices.

Building partnerships is something that is considered to be highly desirable, but is often difficult in practice. The evidence from a detailed study in South Africa (Mutemeri and Chetty, 2012) is that even where partnerships exist, they are one-sided, with the school as the passive recipient and very little dialogue about the content of the courses. Baker (2011) has analysed a number of partnerships and introduces a typology as a way of thinking about how they might best be promoted. He identifies three types of partnership:

- Single-tier – in which university teachers work directly with teachers in order to achieve a common goal;
- Multi-tier – in which there is interaction between actors at different levels within each organisation, working on a range of issues;
- Complex-brokered – in which university or school leaders go outside both institutions to bring in expertise to work with both partners on a set of issues.

In reality, relationships are complex and a particular arrangement might have elements of each type of partnership. Nevertheless, this provides a helpful way of thinking about the challenges facing schools and universities.
The TESSA success is premised on the idea that the change should take place closest to the problem. This approach is described by Elmore (1979) as 'backward mapping'. He argues that organisations have a limited ability to influence individual behaviour and that to be effective, change should therefore focus on the desired behaviours and should involve the people who need to adopt those behaviours. This implies that the sorts of partnerships that are likely to be productive, in this context, are 'single-tier' partnerships, which involve university-based teacher educators working with

classroom teacher. This approach to implementation has been adopted at Egerton University in Kenya, and the TESSA teacher lower secondary science resources have provided a medium and a purpose for discussion.
Partnerships will be beneficial to the participants if there is a clear purpose for the partnership; a shared vision and set of beliefs underpinning the activity; relationships based on trust, open communication, flexibility and responsiveness (Moroney and Boeck, 2012). The TESSA secondary science resources provide the vision and a clearly articulated set of beliefs. They also provide a focus for activity that will lead to the realisation of the vision. One of the purposes of the workshop in Kenya – held off-site – was to start the process of building trust and establishing modes of communication. In their review of school-university partnerships, Mutemeri and Chetty (2012) suggest that a fundamental shift is required in how knowledge about teaching is viewed and valued. University theoretical knowledge should not be valued above school/practitioner knowledge; they need to be linked. The TESSA lower secondary science units aim to make these links. They focus on the practical and therefore have the potential to help university teacher educators develop credibility with teachers and they explain the advantages of particular pedagogies, so that teachers can understand the contribution of theory to improving practice.

Going back to Baker's typology, once teachers and teacher educators have formed the basis of a successful working partnership, it is perhaps appropriate to think in terms of this developing into a 'multi-tier' arrangement with leaders within each institution providing support, encouragement and resources to enable the partnership to flourish. There is perhaps a danger that if the issue is tackled the other way round, by leaders forming partnerships between their institutions, that the university teachers and classroom teachers, will not have ownership of the issue and are less likely to make it work.

Thus, indications from the initial trials are encouraging. Sustainability however, is likely to depend on a number of factors, including the development of strong partnerships between teachers in schools and teacher educators in universities. We have demonstrated in this paper that the TESSA Teaching Lower Secondary Science resources have the potential to support the development of these partnerships as they value practical and theoretical knowledge equally, set out a clear vision of 'good practice' and provide a basis for action.

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