In-service support for a technological approach to science education - Education Research Paper No. 16, 1995, 48 p.

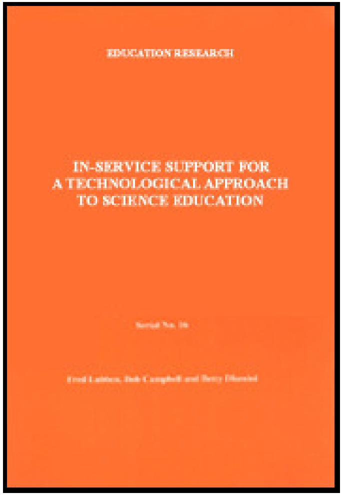

Table of Contents

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Overseas Development Administration

Table of Contents

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Acknowledgements:

This document reports on a research and development project (ODA project ref 5052) to develop and evaluate learning materials using a technological approach to science education and an INSET package designed to introduce these to teaching. The evaluation aimed to identify effective INSET strategies in terms of changes in teacher perceptions and student learning outcomes. Support has been given at various stages of the project by a number of people and organisations.

In addition to ODA funding the project has had financial support from The British Council (Mbabane), Swaziland Educational Research Association (SERA), and the Universities of York and Swaziland. We are grateful for the financial input from each of these sources.

We thank Robin Millar and David Waddington from the University of York for their assistance with the formulation of the project. We are also grateful to Sipho Dlamini, Bongi Putsoa and Dan Mavuso, who shared their experience with the use of contextualised and application-focused teaching materials during the writing and dissemination workshops. The input of in-service science specialists Lawrence Manana (South Africa), Funja O-saki (Tanzania), Thabiso Sephalane (Lesotho) and Partson Shanyinde (Zambia) as peer-reviewers of the INSET manual was invaluable. We particularly acknowledge the enthusiasm of teachers and students who worked with the Matsapha materials and willingly provided us with their views.

Executive summary

1. This project facilitated the production of learning materials for two

units in the junior secondary science syllabus in Swaziland. A cross-section of practising teachers was involved in the creation and trialling of the materials.

2. These new materials, called the Matsapha Lessons, replace the standard SWISP (Swaziland Integrated Science Project) units, and have a technological approach to science, characterised by three aspects:

(i) contextualisation - linking science to everyday life and the experiences that students may have had or are likely to have

(ii) application - helping students to select and apply their science knowledge to solve problems

(iii) investigation - developing science investigative abilities to help students to design and execute valid practical tests.

3. An INSET induction programme, including a detailed workshop manual, has been developed to introduce the materials to teachers. The effectiveness of various features of this induction programme has been evaluated longitudinally in terms of teacher adoption and

implementation of the novel teaching approach, and in terms of student attainment and attitude.

4. Data show that after completion of the induction workshop almost all participating teachers have a good grasp of the contextualised nature of the teaching approach, and two out of three teachers appreciate application and investigation aspects. These proportions remain the same for the reported implementation of the various aspects in teaching, except for investigation which decreases to under half of the cohort. Teachers revert to the perception that any practical work is investigative.

5. The induction strategy included pre-workshop tasks comparing existing practice with the new approach. These tasks were executed by only few teachers, not because of the difficulty of such tasks, but because of the majority's expectation of INSET as 'being told what to do'.

6. Some teachers view peer-teaching with anxiety. However, at the end of the induction workshop and also after class use of the materials, this activity was perceived as valuable in providing a good

overview of the units and of the range of learning activities. Peer teaching is also seen as an effective way to facilitate the understanding and adoption of contextualisation. An understanding of application is aided more effectively through group reflection guided by the INSET leader. The implementation of investigative work in the new materials is aided best through exemplary hands-on practice.

7. The inclusion of a teacher with previous teaching experience with the novel materials as an INSET leader is not necessarily seen as providing much added value. General credibility of INSET providers as knowledgeable of classroom practice is sufficient for most teachers.

8. Some teachers see in-class support by the INSET providers as beneficial for students while others see it as a personal development. Such support is difficult to arrange for practical reasons. The effectiveness of in-class support depends on perceived equality of standing between the teacher and the supporting expert, and the avoidance of a 'teaching-practice situation'.

9. Data show that the effectiveness of the induction strategy is

related to the background of participating teachers. More than half of the INSET group may be characterised as innovators. Classroom innovation is most likely to arise from this type of INSET provision through support of qualified teachers, experienced or inexperienced, who are secure in their science knowledge and are able to see the benefits of new approaches to teaching and learning.

10. For teachers without professional training, or for non-science specialist teachers, such INSET to introduce new teaching methods needs to be preceded by content confidence building, and a basic awareness of teaching methodology.

11. A greater degree of implementation of the new approach may be achieved if the INSET activities consistently focus participants on the improvement of their students' learning, rather then their own teaching.

12. The attainment of the students, using the Matsapha materials, is similar to a comparison group, using the SWISP materials. However, the experimental students are under-performing as they show significantly higher attainment in a benchmark test. This under-

performance is less pronounced for students of teachers who have internalised the new teaching approach more fully. The learning materials do not counteract any gender differences in attainment.

13. Although the Matsapha Lessons explicitly include exercises aimed at the application of science concepts and the design of practical investigations, these abilities are only slightly better displayed by the experimental group than a comparison group, and then mainly amongst the high achievers. However, more students in the experimental group pay attention to procedural issues such as controlling variables and increasing reading accuracy.

14. Observational studies show that student interest and participation is raised by context-led lesson introductions. Effective contexts fall in three categories; those contexts to which students are able to relate, but need not be familiar with; those contexts where students perceive themselves as experts; and those which are contentious, i.e. those referring to a conflict between science and traditional culture or religion.

15. Girls' preferred learning activities are independent of the science

topics. Contextualised learning activities, such as *doing plays* and *reading stories,* are highly favoured by both boys and girls and are specifically able to maintain girls' interest in 'boys topics' such as circuit electricity. Students are indifferent towards learning activities requiring application of concepts, such as *identifying science in everyday life* although they say they value the linkage. A significant gender difference is found in the popularity of investigative work. Although mainly disliked, activities such as *solving practical problems* and *planning an experiment* are more favoured by boys, but only in specific contexts. In such cases, boys overcome the strongly-felt reluctance of taking responsibility for their own independent thinking.

16. Monitoring of teachers' behaviour during their participation in materials provides evidence for considerable professional growth. Teacher acceptance of curriculum innovation is facilitated by their self-perception as curriculum innovators. A tentative model for monitoring and documenting professional development, and relating it to acceptances of curriculum innovation is proposed but this needs to be tested in further research.

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1. Background to the project

This introduction provides the rationale for the project and sets the context.

In many African countries, the majority of young people are unable to progress beyond general education. As it calls on very scarce resources, it is accepted that, to an even greater extent than in industrialised countries, the African curriculum must be relevant to everyday life. Literature on curriculum policy (Swift, 1992) and education policy documents from various countries within Southern Africa (Republic of Botswana, 1993; Government of Mozambique, 1994; ANC Education Department, 1994) show support for integrating technology, particular indigenous technology in the broad sense, in the science curriculum in order to bridge the gap between classroom science, and the students' environment. In Africa, several attempts to renew the curriculum along these lines have been reported. Botswana introduced a "science curriculum with social relevance" (Nganunu, 1988) and in Sierra Leone "a science curriculum that relates to the everyday life of students in their traditional setting" was designed (Baimba et al, 1993). All these papers describe curriculum changes using technological applications from the students' environment as illustrations of the science concepts. This project, however, focuses on context-led materials: it attempts to use everyday technological contexts as *starting points* for the usual concepts covered in a science syllabus.

In Swaziland, teachers and curriculum developers are currently debating how to modify the current Swaziland Integrated Science Programme (SWISP) to make the junior science curriculum more applicable to national needs. These concerns provide sufficient motivation for teachers to participate in curriculum development and INSET work with materials using a technological problem-solving approach. For this reason, Swaziland provided a suitable environment for the development and research study contracted by the Overseas Development Administration.

Evaluation of curriculum renewal attempts in developing countries (see, for example, Vulliamy, 1988; MacDonald and Rogan, 1990) has shown that innovations in the syllabus, examinations, textbooks or teaching strategies are resisted by teachers, unless self-confidence is built through well-planned INSET support. Joyce and Showers (1980) identify four 'levels of impact' of INSET, all of which have to be attained before any impact can be expected in the education of the children. In order to reach these levels, all of the following INSET strategies are needed: presentation of the 'theory' of the innovation, demonstration of skills involved in implementation, simulated practice, and individual feed-back on classroom practice. All of these strategies have been used in the project. As the last mentioned INSET strategy is most labour and cost intensive, the subsequent evaluation has paid specific attention to the contribution which in-class support to individual teachers makes to the modification of teachers' behaviour. The evaluation also specifically explored the added value of teacher-led INSET sessions for promoting teacher change.

Evaluations of INSET projects in developing countries have often been general, post-event descriptions of the INSET contribution to the intended change, usually in terms of 'degree of success'. This project's evaluation differs in three important ways. Firstly, the evaluation includes a long-term aspect, taking advantage of the opportunity to monitor individual teacher change through documenting the teacher's 'stages of concern' (Constable and Long, 1989) before and after participation. Secondly, the evaluation attempts to document various levels of teacher impact *leading up to the desired change in classroom behaviour,* using case analysis. Kinder and her colleagues (1991) developed a practical typology of English teachers responding in specific ways to school-focused INSET. This project adapts this analysis instrument to the context of a developing country. Finally, the extent of the innovation's 'diffusion' across the curriculum is measured in order to gauge the extent of teachers' identification with the new teaching approach.

In many developing countries, girls are under-represented amongst students studying science at tertiary level. For Swaziland, Smith (1988) shows that those girls who do take science at tertiary level perform generally better than their male counterparts. She also identifies a decrease of female interest in school science in Swaziland at lower secondary level. UK based research (Ramsden, 1992) suggests that contextualised science teaching may be more accessible to girls, and, therefore, may maintain a positive attitude to science education throughout secondary schooling.

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2. Objectives

This project includes development and research activities intending to:

(i) develop and trial 2 units of teaching and learning classroom materials on science topics for early secondary school classes, using a context-led technological approach.

(ii) use and evaluate strategies to fully involve practising teachers in the development and the piloting of these materials in their classes.

(iii) develop and implement a package of in-service materials to support the induction of teachers to the use of the classroom materials.

(iv) evaluate the effectiveness of the classroom and in-service materials, documenting in particular the types of change in teaching approaches resulting from the use of these materials.

(v) identify the utility of qualitative long-term evaluation methods for monitoring effectiveness of INSET activities in a developing country context.

(vi) compare student learning outcomes (differentiated for gender) in terms of science conceptual understanding and attitude to science learning of students studying with the new materials with those of students who used standard learning materials.

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3. Personnel and location

The research and development project has been executed primarily by Bob Campbell and Fred Lubben at the University of York and Betty Dlamini at the University of Swaziland, capitalising on the existing British Council funded Link between both institutions, and on previous joint research experience. Extensive use has been made of the expertise of the University of York Science Education Group (UYSEG) in the area of teacher-based development of context-led curriculum materials, and of fundamental research into learning outcomes from investigative practical work. Equally, the expertise of the York-based National Foundation for Educational Research

(NFER) in developing evaluation models for INSET initiatives has been drawn upon. The project has also been built on Swazi research experience into issues related to applying science knowledge to everyday problems. The familiarity of the Swazi researcher with the regional network of science educators has made it possible to involve INSET specialists from various institutions in Southern Africa to provide peer reviews of the materials produced.

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4. Activities and achievements

During two separate workshops in February 1993, two groups of teachers drafted two teaching units of 12 lessons. These workshops were supported by one Swazi and two UK researchers who acted as resource people. The units covered the required content of the Form 2 integrated science syllabus and were designed to replace the standard SWISP units on 'Air and Life' (AL) and 'Electricity' (EL). Drafts of a Teachers' Guide and a Pupils' Workbook for these units were edited in readiness for a third (pilot-induction) workshop for all the participant teachers. Part of the pilot-induction process was a programme of in-class support provided to each participant by the resource people during the period of class trials of the draft materials between March and August 1994.

Feed-back data were collected by the Swazi researcher through classroom observations, and interviews with teachers and selected students. In addition, towards the end of the trial period, a one day experience exchange workshop on the teaching approach was held. Although all these activities were part of the development phase of the learning materials, the induction process (including the in-school support) and the feed-back collection strategies functioned also as a test-run for the INSET model to be used for the subsequent major research study.

Several logistical problems were met during the execution of development phase of the project. For instance, the unavailability of a local video technician and the unreliability of video equipment to provide footage for sample lessons during the pilot phase, made it impossible to use videos as illustrations during the subsequent induction programme.

During September 1993 UK and Swazi researchers jointly edited the lesson materials for the two units incorporating the student and teacher feed back (Campbell et al., 1994a and 1994b). The materials are commonly known as "the Matsapha Lessons". The Matsapha curriculum materials embody what is termed a "technological approach to science education". This umbrella term describes the following characteristics:

(i) contextualisation - linking science to every day life and the experiences that students may have had or are likely to have

(ii) application - helping students to select and apply their science knowledge to solve problems

(iii) investigation - developing science investigative abilities to help students to design and execute valid practical tests.

In terms of contextualisation, lessons focus on events common enough for all pupils to be able to relate to. For example, the problem of a dilapidated car (a skorokoro) failing to start forms the scene for teaching Ohm's law (for the relevant student workbook section, see Box 1). Similarly, the exploration of the 'fizz gas' in cool drinks leads to a lesson on the properties of carbon dioxide (see Box 2).

With regard to application, students are asked to apply their science knowledge to solve problems. The lesson with the skorokoro car ends with asking pupils to explain the starting problem in terms of current and voltage. The lesson with the 'fizz gas' requires them to identify the specific property of carbon dioxide which makes it suitable as cool drink fizz. Revision lessons, such as the one on Silos in Box 3, have been included to purposefully direct pupils to using acquired science ideas to solve a problem. In this case it describes an incident in a traditional underground silo for storing maize over winter.

Investigative skills are developed through planning and carrying out an open-ended experiment. For example, in the lesson on carbon dioxide

(Box 2) pupils are asked to design a method of collecting the fizz gas. In another lesson, they are given the task to investigate the relationship between the number of coils of a heating element and the heat produced, as shown in Box 4.

BOX 1

SKOROKORO

Here is the script of a short play. Read it through. Your teacher may ask some people to act it out.

It is about Musa's skorokoro car which does not start. Musa is bending forwards looking under the bonnet of the car. He fiddles with the engine. He is annoyed because he does not know what the problem is. Phumi walks by.

Phumi: How, Musa, you seem to have a problem.

Musa: (knocks his head against the bonnet) Phumi, you gave me fright. Why can't you just say "Good morning" when you meet somebody?

Phumi: Good morning, Musa.

Musa: Yes, and good morning to you. Thank you.

Phumi: I wanted to ask you. have you got a problem with your skorokoro car?

Musa: No, not really. I am just cleaning the engine a bit.

Phumi: Let's go for a ride then. I like to do some shopping in Mbabane. We need some more mealie meal, otherwise we won't have anything to eat tomorrow.

Musa: I see. Well, actually, at the moment the car has a small...., eh,... It is not that it is sick, but it only has a cold, if you know what I mean.

Phumi: You mean, it does not work, eh? Your skorokoro does not work, eh?

Musa: It does work a bit. When I start the car, it goes: eeeerh, eeerh, eeerh slowly, and then it stops. The thing does not really start. The engine does not get moving round. I don't really know what the problem is.

Phumi: Your skorokoro may have a flat battery. That is what I think. I bet your lights do not work either.

Musa: Well, let us see. No they don't. But what have lights to do with a flat battery? Didn't you say last time that lights need current and not voltage?

Discuss Musa's problem and Phumi's idea. Write down your ideas of what can be done to start the skorokoro.

[leading to the standard Ohm's law experiment relating current and voltage]

BOX 2

FIZZY DRINKS

Coke, Fanta and Sprite are just some of the popular cans of drink in Swaziland. No matter which is our favourite they all have one thing in common.

They fizz! They fizz because they contain a gas. This activity is about that gas.

Discuss in your group how you could collect test tubes of the gas from a can of fizzy drink. Your teacher will show you the apparatus available. You **cannot just pull the** ring tag as most of the gas will escape.

Your teacher will check your method or suggest what to do. **Do not shake the can** but try to collect as many tubes of gas as possible. Keep the tubes **closed with a stopper.**

How many tubes of fizz gas did you collect?.................

Look at the gas. What is its colour?..............................

Smell the gas (remember how to do this!). What is its smell?...

Put a burning splint into the gas. What happens?
....

[leading to further tests of carbon dioxide characteristics]

BOX 3

SILOS

[after completing a fill-in revision sheet for homework]

Your teacher has seen the following article in a newspaper:

There was panic in the Mabuza homestead. Yesterday afternoon Duma (12) and Themba (7) were asked to collect sancoti (special maize). They had to get it from the storage silo (ingungu). The Mabuzas have dug two large underground storage silos. Each can hold about 15 bags. You have to climb down, using a ladder or a rope.

Themba and Duma said they like climbing but yesterday they were in a hurry to go and play soccer. Duma opened the lid of the silo, while Themba collected the ladder. A chicken got curious and saw the maize down below. It jumped in to the silo. Duma climbed down, and Themba followed. When he was on the ladder, Themba felt sick. He quickly climbed out again. He shouted to Duma in the silo: "I am not coming down. You had better lift the bag, and I will take it". There was no answer.

Themba got scared and called for help. Make Mabuza found that Duma had fainted in the ingungu, and she quickly pulled him out. Duma recovered soon in the open air.

The Mabuza family could not explain what happened.

Discuss in your group the following questions

1. Which of the ideas we have learnt about can explain why Duma fainted? Use your homework sheet and list as many points as possible.

2. Why did Themba not faint, but only felt sick?

3. What do you expect will have happened to the chicken? Why?

4. Why is it that the same problems do not happen with modem storage tanks which are above the ground?

Now write a letter to the editor of the newspaper to explain what happened in the Mabuza homestead. You should include **all** the following words:

germination
respiration
oxygen
carbon dioxide
breathing in
breathing out
air
heat
lung volume

BOX 4

HEATER

[after a teacher demonstration showing the heating effect of a current carrying wire]

Plan **your own** experiment to investigate if the **number <u>or</u> size** of turns on the immersion coil has an effect on the heat energy produced. You should consider the following points.

* how many different numbers (sizes) of turns **on** the coil will you try?
* how long will you leave the coils in the water?
* how much water will you use?
* how will you tell if there is a difference?
* what factors will you keep constant?
* what factors will you vary?

7: Use this space to write your plan.

Let your teacher check your plan to make sure that what you wish to do is safe.

8: Use this space for your table of results.

....

9: What conclusions can you draw from your results?

....

10: Explain your conclusions. **11:** How could your plan have been improved?

In general, each lesson starts with an everyday event closely related to the science concept to be focused on. Students are invited to explain the familiar situation but, at this stage, their speculations are not judged on their scientific validity. After study of the relevant science concepts (the theory) in various ways, e.g. through a practical activity, the students are referred back to the initial example and again asked to explain it but, this time, by applying the conceptual understanding they have gained. More examples and detail may be gleaned from the Matsapha classroom materials themselves (Campbell et al., 1994a and 1994b).

BOX 5

Pre-workshop homework exercise

The Matsapha Lessons

Task Sheet

Thank you for agreeing to take part in the INSET activity which will introduce you to the Matsapha Lessons and help you to use the materials to teach your Form 2 science classes about Air and Life and Electricity.

As the first stage in the INSET you are asked to study the enclosed lesson materials from one of the Matsapha Lessons on Electricity (EL6: Mr Hlophe's car Lights) and to compare these with the SWISP materials for Activity 7.4 from Form 2 SWISP. You should do the following:

* Read the lesson materials for EL6: Mr Hlophe's Car Lights.
* Read the Teacher Guide for SWISP Activity 7.4: Conductors and Non-conductors.
* Read the pupil material for SWISP Activity 7.4: Conductors and Non-conductors.

* Consider and make some notes **on your opinions** of the following:

* what is similar about the **materials**?
* what is different about the **materials**?

* what is similar about the **learning activities** suggested?
* what is different about the **learning activities** suggested?
* what is similar about the **teaching approach** suggested?
* what is different about the **teaching approach** suggested?
* what is similar about the **science ideas** pupils learn about?
* what is different about the **science ideas** pupils learn about?

One of the first sessions of the Induction Workshop will ask you to discuss your views with one or two other teachers who have been asked to do the same task. It is thus important that you spend a little time on this and that you **keep some notes of your views** (there are no right or wrong answers!).

Bring your notes and the EL6 lesson materials to the Induction Workshop.

BOX 6	
Workshop programme	
Day One:	
08.30	* **registration**

08.45: session 1	* welcome, domestic arrangements and introduction to the purpose of the workshop
09.00: session 2	* small group discussion of preparatory task (EL6)
09.30: session 3	* plenary discussion of preparatory task (EL6)
10.00	* **coffee**
10.30: session 4	* demonstration-teaching and discussion of a contextualised lesson (EL6)
11.15: session 5	* presentation on documentation of Matsapha Lessons
11.45: session 6	* small group discussion on different contextualised lessons (AL1, AL5)
12.15	* **lunch**
13.15: session 7	* demonstration-teaching and discussion of an application lesson (ALII)
14.30	* **tea**
15.00:	* demonstration-teaching and discussion of an

session 8	investigation lesson (EL7)
16.15: session 9	* review of day and task allocation
Day Two:	
08.30: session 10	* overview of the day
08.45: session 11	* peer-teaching and discussion of contextualised lessons (EL1-EL3)
10.00	* **coffee**
10.30: session 12	* peer-teaching and discussion of contextualised lessons (EL4-EL9)
12.30	* **lunch**
13.30: session 13	* small group practice and discussion of an investigation lesson (EL10)
14.45	* tea

15.15: session 14	* small group practice and discussion of an application lesson (EL11)
16.30: session 15	* review of day and task allocation
Day Three:	
08.30: session 16	* overview of the day
08.45: session 17	* peer-teaching and discussion of contextualised lessons (AL2-AL4)
10.15	* **coffee**
10.45: session 18	* peer-teaching and discussion of contextualised lessons (AL6-AL10)
12.30	* **lunch**
13.30:	* familiarisation with total pack of Matsapha Lessons;

session 19	issues raised about their use in teaching
14.00: session 20	* brainstorming on teaching ideas on different science topics
14.45:	* **tea**
15.15: session 21	* evaluation
16.15: session 22	* refund of travel expenses, arrangements for distributing workbooks and in-class support

In preparation for the induction workshop during which a new cohort of teachers were to be introduced to the Matsapha materials, an extensive INSET-pack (Campbell et al., 1994c) was prepared for use by the INSET providers. This pack includes a pre-workshop homework exercise (see Box 5), a detailed programme (see Box 6) and background reading materials for the INSET providers.

BOX 7

Session 11: Peer-teaching and discussion of contextualised lessons 08.45 - 10.00 a.m. (Day 2 of Induction workshop)

ACTIVITY	OUTLINE	KEY POINTS
Peer-teaching by three participants followed by plenary discussion.	Participants offer short (15 minute) presentations of contextualised aspects of 3 lessons (EL1 - 3). Plenary discussion after each presentation considers the merits of the teaching approach.	The unit provides several contextualised learning activities. Contextualised learning can be approached in several ways.

The main purpose of all the peer teaching sessions is that participants realise that they themselves are able to teach lessons with the suggested new approach.

In the introduction to this session you may wish to take the following approach:

* Review the guidelines for the peer teaching:

- sessions of 10-15 minutes.
- only the new aspects of the lessons should be covered.
- non-presenting participants will act as students.
- "students" should voice common science misconceptions where appropriate.

* Ask a participant to be a time keeper allowing at most 15 minutes for a presentation, and at most 25 minutes for presentation plus discussion.

* Make clear that after the peer-teaching the discussions will focus on expected problems or advantages of adopting the demonstrated approach (OHP6).

During the discussions after the peer-teaching the following points need to be raised:

* Many of the possible pitfalls in teaching and concept development are highlighted in the Teachers' Notes for each lesson.

* Stress, where appropriate, how tempting it is for a teacher to pronounce prematurely if suggested explanations are scientifically

correct or incorrect.

* Similarly, indicate the cases where misconceptions have been or can be voiced during the introduction, and addressed and corrected at the end of the lesson.

* Some of the following questions may be raised by participants or introduced, by the leader:

- Is the introduction motivating?
- Is the science content at the right level, and in a logical sequence?
- Do the various parts of the lesson flow naturally from one to the other?
- Are any problems expected in obtaining or using the required apparatus?
- Is the language level of the text in the Student Activity Guide appropriate?
- How does learning from this lesson differ from the corresponding SWISP activity?

Materials provided: - OHP6 (Task Sheet 2: identify teaching and learning opportunities in Matsapha Lessons).

Materials required: - Complete Teachers' Guide for the unit "Electricity".

Workshop Leader's own notes:

The INSET-pack further provides session-by-session guidance on the presentation method of small-group discussion and plenary follow-up of the pre-workshop task, introductory familiarisation with the structure and different aspects of the materials, demonstration teaching lessons, peer-teaching lessons (for an example see Box 7), hands-on practice of investigations and brain-storming activities for contexts for various other science topics. The pack also provides OHTs, participant hand-outs and an end-of-workshop evaluation instrument.

At a 3-day workshop in early February 1994, a group of 17 science teachers from 10 schools were introduced to the Matsapha materials by a Swazi science educator who had not been involved in the development of the materials and a teacher who had participated in the pilot phase.

Research instruments were developed and used to evaluate the induction strategy, including the format and content of the INSET-pack. Data were collected on teachers' and INSET providers' expectations and experiences through pre-workshop and post-workshop interviews, questionnaires and audio-taped teacher group discussions. Extensive field notes were collected during the induction workshop.

The printing of 1300 classroom student workbooks for each of the two units was arranged locally. These were later delivered to participating schools. All participants who implemented the new materials were supported in their classes at least once by the INSET providers during the period from February to June 1994. However, teaching schemes of the teachers participating in the induction workshop differed considerably. This resulted in problems with planning efficiently the in-class support by the INSET provider, and collecting classroom feed-back by the researchers.

Feed-back on the effectiveness of the INSET strategy has been collected through interviews with INSET providers and teachers, and the occasional observation of an INSET-provider supporting teachers in action. Science Educators in Lesotho, South Africa, Tanzania and Zambia have provided peer critiques of the INSET-pack, illuminating the generalisibility of the proposed INSET strategy. In July 1994, the researchers completed the data collection on the impact on classroom practice by interviewing all participating teachers, establishing their 'concerns and anxieties' after using the materials. Diffusion of the teaching approach to other syllabus topics has been traced. Analysis of these data to relate specific characteristics of the INSET package and the readiness for change of the individual participating teachers has been completed during the subsequent 8 months.

In order to gauge the effects of the Matsapha materials on student learning, four questionnaires were constructed during March 1994. Three of these were designed to assess conceptual understanding and one to probe students' views on science learning activities. After piloting, the revised questionnaires were delivered by June 1994 to the 10 participating teachers covering 16 classes, equally split between those who used the Matsapha materials and those who used the standard SWISP materials. The main collection of written data took place between June 1994 and February 1995. A total of 600 students in 16 Form 2 classes have been involved. About half of these provided a complete set of questionnaire responses. Also during this time, 20 student interviews were scheduled.

After coding of responses, in April to June 1995, a comparative analysis for the experimental and comparison groups has been undertaken for the assessment of science understanding. Simultaneously, student preferences of various learning activities included in the Matsapha materials have been analysed.

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5. Findings on in-service strategies

One of the aimed for outcomes of the project was the evaluation of the INSET strategy through an identification of the changes, if any, in teachers' perceived and actual teaching approaches which might have arisen as a result of the INSET and their use of the new curriculum materials. A second was an analysis of the utility of qualitative long-term evaluation methods for monitoring the effectiveness of INSET activities in a developing country context. This section of the report relates to these aspects of the project.

The 17 teachers that participated in the INSET were monitored closely with a view to determining firstly, if they understood and accepted the purposes and approaches of the new curriculum and secondly, the extend to which the desired outcomes of the INSET were subsequently reflected in their teaching and professional behaviour. In approaching these aspects attempts have been made to fit the field data to two theoretical models. Firstly, a model of professional development related to stages of concern as discussed by Constable and Long (1989) and secondly a practical typology of INSET outcomes model developed by Kinder *et al.* (1991). The approach taken used data collected at various stages in the processes of introducing and implementing the innovation.

Data was collected both formally and informally, from the group as a whole and from individual teachers. Formally, data was collected by individually completed, end-of-workshop questionnaires and by three rounds of semi-structured personal interviews in school, the first carried out before the INSET, the second after the INSET event but before any teaching with the new materials had been undertaken, and the third carried out in schools after teachers had taught with the new materials. Most interviews were taped and transcribed others were recorded in note form. During the final session of the INSET workshop, group data was gained through a formal evaluative discussion. Informal data collection was through casual conversations and discussion with teachers before, during and after the INSET event and via observations of workshop activities and classroom teaching. Due to limits on time and resources and various practical considerations not all teachers were interviewed in each round of data collection nor were all those interviewed asked the full set of interview questions. However, although the data set may be seen as incomplete it is still substantial. In addition to observation records, field notes and pre-INSET task records, it consists of 17 teacher questionnaires and 37 teacher interviews, 30 of which were conducted after the INSET. Here it needs to be noted that some teachers were difficult to contact before the INSET and so this data set is the most incomplete (it is also seen as of less importance than the post-INSET data). It also needs to be noted that once it was judged that a teacher had established teaching inconsistent with the intent of the innovation they were not interviewed again. Incomplete interviews arose when it became clear to the interviewer that the teacher had little more to contribute or when the teacher had no more time to spend with the interviewer, often as a result of giving extensive answers to early questions. The maintenance of goodwill and cultural sensitivity were important elements in judging when to terminate an interview.

The report here deals with the following aspects:

(a) teacher expectations of INSET
(b) teacher opinion of the three characteristics of the new curriculum
(c) teachers' evaluation of the INSET workshop

(d) teachers' understanding and implementation of the new teaching approach
(e) teachers' advocacy of the new curriculum
(f) how the data fits the theoretical models
(g) the utility of qualitative long-term evaluation methods

Before turning to the data it is of value to note the backgrounds of the 17 teachers who attended the INSET and who then went on to work with the new materials in school. Four categories of teacher were recognised as being represented at the INSET. These are seen as beginning teachers (4), novice teachers (4), experienced diploma teachers (5) and experienced degree teachers (4). Table 1 describes their characteristics and lists their reference code numbers which were used throughout the study. This characterisation and the teachers reference codes are used at several stages in the presentation of the analysis which follows.

Table 1 Categories of teachers who participated in the INSET.

Beginning	Novice Teachers	Experienced Diploma	Experienced Degree

Teachers		Teachers	Teachers
untrained, inexperienced degree holders	trained but inexperienced degree or diploma holders	trained diploma holders with long experience	trained degree holders with long experience
4	**4**	**5**	**4**
01 10 12 17	03 05 09 14	02 04 11 13 16	06 07 08 15

figures in bold are the numbers of teachers in each group
other figures are the reference code numbers of the teachers

(a) teacher expectations of INSET

Teachers were informed about the INSET workshop by word of mouth from their head teacher or by one of the project team who visited the school. They were informed that the workshop would introduce them to new curriculum materials and prepare them to use these in school. They were asked to carry out a pre-workshop exercise to compare a SWISP lesson with a Matsapha lesson. In fact, only half the participants completed the pre-workshop task. This and the feedback collected at the end of the workshop suggested that most teachers had a clear expectation that they would be passive participants in the INSET and expected just to be told about the curriculum rather than have a more active role in the INSET. Teacher 02 was typical in expecting to "listen to lectures". Teacher 09 represented a minority who expected to "do a few practicals on Electricity and Air and Life". Most teachers thus described the workshop as "not exactly what I expected, especially the peer teaching" (teacher 15). While the more active role was not expected, it was appreciated by many to be "very worthwhile" (teacher 13).

The induction strategy included pre-workshop tasks comparing existing practice with the new approach. These tasks were executed by only few teachers, not because of the difficulty of such tasks, but because of the majority's expectation of INSET as 'being told what to do'.

Noting that most teachers expected a passive INSET experience it is of interest that only 3 teachers suggested that notification of the expectations of the workshop might have been clearer. A further 3 wished for the materials to be issued prior to the workshop rather than in the course of the workshop. The main demand in terms of how to improve the INSET was for more time for peer teaching: a novel INSET experience for all the teachers and which, as noted later, was seen as the most helpful workshop activity.

(b) teacher opinion of the three characteristics of the new curriculum

Table 2 summarises the opinions of the teachers at the end of the workshop on the three characteristics adopted as the technological approach of the Matsapha materials. It is clear that all the features are welcomed by the majority of members of all the groups of teachers and that while a few teachers see difficulties and challenges, mainly with investigations, most see opportunities to improve motivation and bring relevance to learning.

Table 2 Teachers' opinions of the characteristics on the Matsapha materials

Group	Contextualisation	Application	Investigation

Beginning Teachers (4)	2 good 1 excellent 1 difficult	1 good 1 excellent 1 helps learning	1 good 1 motivating 1 desirable 1 students can be uncertain
Novice Teachers (4)	1 good 1 perfect 1 motivating 1 helps understanding	1 good 1 aids learning 1 helpful 1 useful	2 good 1 motivating
Experienced Diploma Teachers (5)	2 good 1 very good 1 to be encouraged 1 more interesting	3 good 1 quite good	1 good 1 quite good 1 positive 1 exciting 1 guidance needed
Experienced Degree	1 very good 1 enjoyable 1 motivating	2 good 2 relevant	2 good 1 helpful 1 pupils will

Teachers (4)	1 relevant		have to think a lot

Immediately after the INSET the views of the four groups of teachers were collected on their confidence to teach the two Matsapha units to their Form 2 classes. The evidence indicates that all but one of the teachers felt confident to teach both units and that some expressed the view that they were very confident or even highly confident. The data suggests that, perhaps unsurprisingly, the experienced degree teachers may have a higher level of self confidence in their teaching ability than the other groups.

(c) teachers' evaluation of the INSET workshop

The INSET activity incorporated a number of different professional development strategies. Of particular interest was the perceived value and effectiveness of these, and in particularly simulated teaching (=peer teaching), teacher-led sessions and in-school support.

From the post workshop evaluation questionnaires more than half the group spontaneously suggested that peer teaching was the most helpful activity. When selecting from amongst eight different workshop activities, all but one teacher chose peer-teaching amongst their two most helpful activities. Reasons why peer teaching was seen as helpful were because it:

(1) provided experience of teaching;
(2) enabled learning from others;
(3) covered the curriculum;
(4) provided time to consolidate learning;
(5) built confidence.

Although peer teaching was welcomed, over 50% also saw this as the most difficult activity, because it:

(1) was unfamiliar;
(2) required a change from a traditional teaching approach;
(3) opened up discussion on teaching performance;
(4) was done with little preparation time.

The main critique of the peer teaching was that it required more time to be devoted to it.

Peer teaching is considered to be a very worthwhile INSET activity to provide an overview of teaching units and of learning activities. Appropriate time needs to be given to it.

Some of the INSET workshop sessions were led by a teacher who had been involved in the development of the curriculum materials and had taught the trial units. There were many positive comments made about his contribution during interviews with teachers after the workshop and after they had taught the new units. His contribution was seen by the majority of teachers as uniquely helpful as he:

- knew the school situation and how pupils actually responded;

- gave the feeling that if it was possible for him then it was also possible for other teachers to teach with the new materials.

However, not all teachers felt the need for his sessions. Most considered that the INSET leader (an experienced and respected teacher educator) could have led his sessions equally well. Others were confused by the input as they had not yet come to terms with the curriculum (a timing issue and not a staffing issue).

The main contribution to the INSET of the practising teacher leading INSET sessions was one of building the professional confidence of the participants. However, most participants suggested that any INSET provider with general credibility as a classroom practitioner could have offered the demonstration teaching sessions equally well.

In-school support was provided to teachers once they started to use the new materials in their schools. This was provided by the INSET workshop leader. There was some apprehension among some teachers about such a visit. The concern was that the visitor might evaluate or even take over the teaching. These concerns of a small minority were more than balanced by those who welcomed the opportunity to get feedback, to have another adult in the class and to share teaching. As it turned out, visits were difficult to arrange. Several wasted journeys were made to distant schools only to find teachers absent or sudden timetable changes resulting in no opportunities to work with teachers as planned. Consequently, not all teachers were visited and not all those that were visited were teaching with the Matsapha materials on the arranged visiting day. All but one of those supported in class (who did not understand the purpose of the visit and thought she was being checked up on) spoke highly of the class visit. Some reported the benefits of help in class and the positive influence on pupils while others spoke of the opportunity to gain skills and to learn from demonstration teaching. Clearly, some teachers saw the purpose of the visit to be for the immediate benefit of the pupils while others saw it as an aid to their own professional development and of longer term benefit to pupils.

The evidence is that in-school support is valued and important. It is likely to be of greatest benefit when its purpose is clearly understood to be different from a 'teaching-practice situation'. Great difficulties must be overcome to make the best use of the time of INSET staff.

As discussed below (section d) a key factor to the success of the curriculum was the extent to which teachers understood the features of the materials. Data collected after the workshop and after teachers had taught the units throws light on those INSET workshop activities which teachers considered important to improve their understanding of contextualisation, application and investigation.

With regard to contextualisation, peer teaching and INSET leader presentation are perceived as the only contributing activities, with teachers' opinions about equally divided between the merits of these two. Opinions about the development of understanding of the applications approach were more varied. One or more teachers perceived teacher-led presentations, peer-teaching and laboratory practical work as the most useful aid to understanding. The bulk of opinion, however, supported INSET leader presentations. Here it needs to be noted that several teachers considered that they had a full understanding of teaching about applications before attending the workshop (see below). All the responses about investigations record that laboratory practical work is the most useful activity aiding understanding.

The above underlines the importance of peer teaching activities in an INSET strategy to familiarise participants with contextualisation. However the value of expert input and practitioner-led sessions are most effective ways of conveying teaching approaches to applying science to everyday problems. The opportunity for practical

experimentation aids the acceptance of the investigative aspects. We argue that it is the blend of activities that can give strength to INSET. The right blend may have a greater effect than the sum of the parts.

(d) teachers' understanding and implementation of the new teaching approach

A key element to the success of the curriculum was seen to be the extent to which the teachers understood the features of the Matsapha materials and interpreted the learning approach in the way intended by the development team and promoted in the INSET workshop. To gain insights into this, an analysis of the INSET feedback questionnaires, post workshop interview transcripts and post teaching interview transcripts was carried out. In analysing the pre-teaching documents what was being looked for was evidence of an understanding of the concepts on contextualisation, application and investigation and how teaching might be transacted in the classroom. In analysing the post-teaching data what was being looked for was evidence that what had gone on in the classroom could be identified as contextualisation, application or investigation.

While there is evidence that four out of five teachers understood contextualisation after the workshop only two out of three teachers understood application and investigation. These proportions for contextualisation and application did not change after teaching but those for investigations did. Here less than half the teachers showed an understanding.

High levels of understanding of the Matsapha approach after the INSET workshop translated into high levels of implementation except for the investigative work. Here most teachers were unable to give relevant examples from their teaching and frequently equated investigations with any type of practical work. Those unable to convey a practice or understanding of application saw this as merely an illustration of a concept unrelated to any problem solving situation. Misunderstandings of contextualisation tended to result from confusion with application.

Here it might also be worth noting that no teacher claimed to have come to the INSET event with an understanding of contextualisation but 6 claimed an understanding of application and 2 an understanding of investigation.

(e) teachers' advocacy of the new curriculum

In relation to the wider adoption of the new approach, we were interested in the extent to which teachers tried to alter the practice of their teaching of other topics to reflect the technological aspects of the Matsapha materials. In order to promote wider practice, some time during the INSET workshop was devoted to brainstorming appropriate contexts for lessons on other topics.

More than a third of the teachers were able to cite examples of contextualised lessons in other science topics they taught. A quarter stated that they had introduced applications to other lessons and a third claimed to have carried out investigations with pupils not following the Matsapha curriculum. What needs to be kept in mind here is that, in the light of data presented above, their notions of contextualisation, application and investigation may not be uniform and at one with those of the curriculum developers.

The teachers were also asked about the level of interest shown by their colleagues in the Matsapha materials and the extent to which they had tried to interest them. While few teachers reported selfinitiated interest by their colleagues more than half reported that they had tried to interest colleagues.

There was no expectation that teachers who had not attended the workshop would use the new materials. One teacher commented that "Other teachers did read but since they were not at the workshop they did not use this method" and indeed the need for workshop support was emphasised by another teacher who commented "I think that there will be some problems using it without a workshop". Less encouraging comments reported no interest or feedback from colleagues when shown the new materials, one teacher explaining this because "Teachers are lazy. It is not easy to teach a dog new tricks". More encouraging were comments such as "The HOD has seen them. He liked the approach" and "Yes, they are asking me why only these topics".

All this points to a low level of curriculum diffusion to other than pupils taught by teachers working with the new materials. Clearly, a brainstorming session as a practice of creative thinking and resulting in a list of ideas as a teaching resource has a limited effect on the transfer of a new teaching approach to other topics. Also, it seems

accepted by participating teachers and their colleagues that specific induction is needed before adoption of a new teaching strategy may be expected.

(f) how the data fits the theoretical models

The actions and statements of teachers recorded in interviews undertaken after they had the opportunity to teach the new curriculum have been mapped against a range of stages of concern as recognised by Constable and Long (1989). These stages can be described as follows:

0 **awareness:** shows little interest in the innovation and is not concerned with its implications

1 **informational:** shows a general awareness and interest in the innovation but only in the gross features.

2 **personal:** is concerned with personal adequacy to cope with the innovation and the extent to which any required change will conflict with present practice

3 **management:** is concerned with implementation of the innovation and managing the tasks required

4 **consequence:** concern is for the students in the teacher' classes and the impact of the innovation on their learning

5 **collaboration:** concern is with co-ordination and co-operation with others regarding the innovation

6 **refocusing:** concern is with the widespread benefits of the innovation and its potential to replace current practice

Table 3 is arranged so that the teacher codes appear in category order across the top. The 3 marks in the table indicate where there is evidence to indicate that the teacher exhibits this level of concern. The • indicates that the evidence is such that this is a major area of concern.

Teacher	01	10	12	17	03	05	09	14	02	04	11	13	16	06	07	08	15
Stages of Concern																	

0. awareness	✔●	✔●		✔●							✔●	✔●					
1. informational																	
2. personal			✔		✔●	✔●		✔	✔	✔			✔	✔	✔	✔	✔
3. management			✔		✔	✔		✔	✔	✔			✔●	✔	✔	✔	✔
4. consequence			✔●		✔		✔●	✔●	✔●	✔●			✔	✔●	✔●	✔●	✔●
5. collaboration			✔				✔	✔	✔	✔			✔	✔			
6. refocusing						✔		✔	✔●	✔●				✔●		✔	✔
Understanding of Features																	
contextualisation			✔		✔	✔	✔	✖	✔	✔			✔	✔	✔	✔	✔
application			✔		✖	✔	✔	✖	✔	✔			✔		✔	✖	✔
investigation					✖	✖	✔	✖		✔				✔	✔	✖	✔
	01	10	12	17	03	05	09	14	02	04	11	13	16	06	07	08	15

✔ = evidence for stage of concern/feature of curriculum understood

● = main stage of concern

✖ = feature of curriculum not understood

For example teacher 10 (a beginning teacher) never progressed beyond an awareness of the innovation as evidenced in his post-teaching interview response of:

> It is almost the same as SWISP, isn't it? I only think that the Matsapha lessons are simpler. But I failed to separate the SWISP

Although he received the materials to use in class he did not use them as intended and effectively dropped out of the project. On the other hand teacher 06 (an experienced degree teacher) presented evidence for him to be seen as one who saw the impact of the innovation on his students and the universal benefit of the new curriculum as indicated by the following interview comment:

> One thing I like about these new materials is that it increases motivation for the students. If it could only be broadened to other topics. To take over from SWISP.

The table also includes an indication of whether there is evidence to indicate if a teacher understood or misunderstood any of the three characteristics features of the new curriculum. Thus while teacher 14 (a novice teacher) welcomed the potential positive impact of the innovation on his pupils the evidence from interview indicates that he did not internalise the ideas of contextualisation, application and investigation. Teacher 09 in the same category had the same concern but she indicated an understanding and adoption of the approach being advocated.

From this mapping of concerns, stances to the innovation of the teachers in the four categories (beginner, novice, experienced diploma holder and experienced degree holder) can be recognised. These are illustrated in Table 4.

Table 4 Stance of different teacher categories towards the curriculum innovation

	Beginning teachers	**Novice Teachers**	**Experienced Diploma Teachers**	**Experienced Degree Teachers**
Rejecters	01 10 **17**		**11** 13	
Personal		03 **05**		

Users					
Manager Adopters				**16**	
Innovators	**12**	**09** 14	**02** **04**		**06** **07** 08 **15**

- the numbers represent teacher codes

- bold code numbers are those teachers who understood at least two of the three of features of the curriculum innovation

- underlined codes are teachers who saw the curriculum innovation being appropriate and necessary for the system as a whole

All but one of the Beginning Teacher group (untrained inexperienced degree holders) rejected the innovation. For most this can be explained by a lack of insight into the advantages and disadvantages of one teaching approach versus another. It is argued that these teachers do not adopt a teaching approach for any special educational reasons. The two experienced diploma holders who also rejected the innovation, one of whom provided evidence that she understood its features, did not have secure backgrounds in science or mathematics and had stronger personal and professional commitments to teaching arts subjects. Both underprepared groups have survival skills which they are reluctant to change regardless of the quality of education they are providing. This is not yet a concern for them. The one exception in the group of Beginning Teachers who has been classified as an innovator was characterised by her consistently expressed concern to provide the best possible science education for her pupils, rather than focusing on the innovations' requirements for the teacher practitioner.

Two Novice Teachers understood the purpose of the curriculum but had concerns dominated by their personal adequacy to cope with its demands. Two others were seen as innovators. One of the five experienced diploma teachers is seen as being concerned with managing the innovation whereas another two exhibit not only an understanding of the characteristics of the innovation but look to its more widespread adoption and influence on the science curriculum as a whole. These two are part of a group of 9 (more than half the original INSET group and nearly three quarters of those that used the materials in school) whom we characterise as innovators in that they all have a concern to improve the learning of students. This is well illustrated by teacher 2 who stated:

> The main thing is the pupils. Do they understand? That is what I want.

It is of note here that all the Experienced Degree Teachers fall into this group and that all the group except one of the Novice Teachers interprets the characteristics of the curriculum as intended. Three of the 9 have a general concern for the quality of science education and see the type of curriculum which the project has introduced as reflecting the needs of system as a whole.

The mapping of the data onto a professional concerns grid has allowed the identification of various stances to the innovation. An implication of this is that classroom innovation is most likely to arise from this type of INSET provision through support for qualified teachers, experienced or inexperienced, who, it is argued, because they are secure in their school science knowledge and have had the opportunity to reflect on practice are more likely to see the benefits of new approaches to teaching and learning and have the confidence

to try these with pupils. Furthermore, it is emphasised that introducing new teaching methods needs to be preceded by content confidence building and a basic awareness of teaching methodology. More effective implementation may be achieved if the INSET activities consistently focus on the improvement of learning rather than teaching.

(g) the utility of qualitative long-term evaluation methods

This section looks back at the methods used to monitor and evaluate the INSET and considers the possibilities for the more widespread adoption of long term qualitative evaluation methods in developing country contexts. There is no attempt made here to compare the merits of qualitative and qualitative evaluation methods. The first point to note here is that our data collection has been collected from teachers and not pupils or classrooms and relies on what teachers say and claim to do. It is thus an indirect reflection on practice. As such it has weaknesses but these are shared with other evaluation methods which centre on teacher feedback. A strength is that data is collected over time and so there is a greater chance that an evaluator can gain a sense of the reality of understanding and implementation of a curriculum innovation in a natural teaching context rather than capture the after-glow of a positive INSET experience orchestrated by enthusiasts and usually (and in our case) away from the reality of schools and pupils. Also, opinions and judgements are likely to have matured and understandings consolidated with time. Teachers can be given the opportunity to articulate their understandings and to express their opinions in a variety of ways which need not be restricted by closed questionnaires, time or ability of expression in writing. The task of the evaluator is to formulate questions, probe for answers through a variety of means, encourage openness and interpret responses. Having said that, and reflecting on the positive outcomes of the adoption of the long term qualitative evaluation in this project, a number of points must be made

- questionnaire, interview and observation methods were used

- considerable time was spent by experienced staff on the design, construction and piloting of the questionnaire and interview schedules

- experienced research staff conducted and transcribed the interviews

- not all teachers who participated in the INSET contributed a full set of data to the evaluation

- data analysis though done by experienced staff was time consuming

- the long term nature of the evaluation revealed aspects not evident in the data collected during or immediately after the INSET and between the INSET and when teachers started teaching with the materials the INSET introduced

- the unrestricting nature of the data collection methods allowed for insightful comment from teachers and free interpretation by the researchers

- dialogue with teachers was facilitated by the non threatening position of the evaluators and the trust built up between teachers and interviewer INSET providers and evaluators were identified to teachers and their roles explained at the outset

Our contention is that qualitative long term evaluation methods can be applied to effect in a developing country context but that a number of conditions will need to be satisfied if a high level of success is to be achieved.

The conditions for successful use of longitudinal INSET evaluation methods are that: • the teachers have a high level of personal trust in the evaluators so that they are secure in their knowledge that feedback is confidential and will not be used against them but to help improve systems; • the evaluation should be done by people other than the INSET providers; • the evaluators are trained and can achieve a standard of practice likely to achieve meaningful outcomes; • the evaluators have adequate time and resources to carry out the study;

• the teachers know what is being evaluated, the methods being used, the time scale of the exercise and its purposes.

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6. Findings on student learning

The effects of the new science curriculum materials on student learning have been considered in two ways:

(a) the effects on learning through these new materials compared with the SWISP approach in terms of science conceptual understanding;

(b) the difference in the effect of SWISP and the new approach on students' attitude to science learning.

(a) the learning effects of the Matsapha approach compared with the SWISP approach in terms of science conceptual understanding

An experimental group of just over 300 students from 8 classes at 4 schools used the Matsapha materials for the units 'Air and Life' (AL) and 'Electricity' (EL). A comparison group of almost the same number of students from 8 classes from a different set of 4 schools used the SWISP materials which covered the same science concepts. Each group represented rural, peri-urban and urban schools. No attempt was made to stratify the sample of schools on the quality of their examination results.

For each unit, test instruments each with three components were administered as an end-of-unit test by the class teachers of both groups. Firstly, each test consists of around ten standard, short-answer, examination-type questions designed to measure concept achievement. The questions required recall (e.g. what is the name of a negatively charged particle; a test for carbon dioxide), understanding (given a parallel circuit with bulbs and switches; which bulb will light if a specific switch is opened) and application (explain if one can use a low resistance wire in an electric kettle; explain how to discriminate between two colourless gases). A standard marking scheme was applied. As an alternative to pre-testing, a benchmark of performance of both groups was established by testing both on a different topic. This topic ('Detecting the Environment' (DE)) was taught to both groups with the SWISP materials.

In addition to the standard attainment questions each test paper contained questions to collect data on students' abilities in problem solving. For example, one question provided pupils with a set of related statements containing true science ideas and asked them to select the statements needed to solve the given practical problem and then to propose a solution. A third form of question asked pupils to write a plan of an experiment to test a hypothesis. Answers to these questions were coded and provided evidence of students' investigative ability.

In order to compare student responses for the various units, only the respondents with a complete set of answers to all three tests were considered in the following analysis. Thus the experimental group comprises 104 students from 3 schools, and the comparison group includes 184 students from 3 schools.

Table 5 Test scores of experimental and comparison groups for Air and Life, Electricity and Detecting the Environment teaching units.

	Experimental group (n=104)	**comparison group (n=184)**
Air and Life (maximum 15 points)		
mean	6.06	6.66
standard deviation	2.36	2.29
standard error of mean	0.23	0.17
		t=-2.09
		p=0.04
Electricity		

Electricity (maximum 11 points)		
mean	4.10	4.43
standard deviation	2.35	2.27
standard error of mean	0.23	0.17
		t=-1.17
		p=0.24
Detecting the Environment (maximum 11 points)		
mean	**5.66**	4.90
standard deviation	1.89	1.80
standard error of mean	1.80	0.13
		t=3.34
		p<0.01

Table 5 presents an overview of the data on pupil attainment. A striking point is that the mean level of pupil attainment is low and often very low. It also shows that there is no significant difference at the 5% level between the performance of both groups on the Air and Life unit or on the Electricity unit. For the SWISP unit on Detecting the Environment. however, the experimental group significantly out-performs the comparison group though the mean is just above the 50% mark. This seems to suggest that the experimental group, learning through the Matsapha materials, achieve less than might be expected.

When comparing the performance of students in each of the experimental schools with the performance of the whole comparison group (not shown here), the achievement on the baseline (DE) test is very similar: achievement in each experimental school is significantly better than for the comparison group. However, the achievement for the AL and EL units falls in particular in those schools, where the teacher only partly adopted the Matsapha teaching approach.

The attainment of the students, using the Matsapha materials, is similar to a comparison group, using the SWISP materials. However, the experimental students are under-performing as they show significantly higher attainment in the benchmark test. This under-performance is less pronounced for students of teachers who have internalised the new teaching approach more fully. This suggests that student performance may improve when teachers are given more time to gain confidence in using the new materials.

In designing the Matsapha materials one assumption was that they might appeal more to girls than the more traditional SWISP workbooks, and so aid motivation and hence learning. With this in mind the attainment was looked at again in relation to gender differences. Table 6 presents data on attainment of boys and girls in the experimental and comparison groups for the AL, EL and DE units.

Table 6 Test scores of boys and girls in the experimental and comparison groups for Air and Life, Electricity and Detecting the Environment teaching units.

	experimental group (n=104)		comparison group (n=184)	
	boys	girls	boys	girls

	(n=46)	(n=58)	(n=95)	(n=89)
Air and Life (maximum 15 points)				
mean	5.91	6.17	6.51	6.80
standard deviation	2.40	2.35	2.22	2.37
standard of error of mean	0.35	0.31	0.23	0.24
		t=-0.55		t=-0.87
		p=0.58		p=0.38
Electricity (maximum 11 points)				
mean	4.43	3.83	4.56	4.29
standard deviation	2.32	2.37	2.19	2.36
standard error of mean	0.34	0.31	0.22	0.25
		t=1.31		t=0.79
		p=0.19		p=0.43
Detecting the Environment (maximum 11 points)				

mean	6.35	5.12	5.28	4.49
standard deviation	1.90	1.72	1.74	1.78
standard error of mean	0.28	0.23	0.18	0.19
		t=3.41		t=3.04
		$p<0.01$		$p<0.01$

Table 6 shows clearly that while the boys do better than the girls in both samples in the Detecting the Environment (DE) test, their performance in the other tests is indistinguishable. This indicates that, indeed, the girls' performance improves relatively to the boys' when using the Matsapha materials, but so does their performance when using the SWISP materials.

The notion that achievement by boys and girls is affected differently by the teaching approach does not find support. Similarly there is no indication that any variation in the level of teacher acceptance of the Matsapha approach is reflected in different outcomes for boys and girls.

But what of the ability of pupils to apply their science knowledge by selecting appropriate science ideas to solve problems or their competence to design valid experimental tests? This is reported in detail elsewhere for the EL test questions (Lubben *et al,* 1995). Suffice it to state here that no difference between groups is apparent in pupil competence in identifying and using science ideas relevant to a every day circuit, despite this being an aspect of the Matsapha materials but not of the SWISP materials. Essentially, this competence is randomly distributed across the ability range for both the experimental and comparison groups. More strikingly, when students were asked to sketch an electrical circuit, the data show that the circuit diagrams bear no relation to the science statements selected as relevant to the problem.

The Matsapha materials have not improved students' competence in applying science ideas to solve everyday problems. The assumption that the application of relevant science ideas to solve a practical problem is facilitated by guiding students to consciously select relevant ones from a set of true science statements, is not supported by the data. Students do not see any relationship between the two tasks.

With regard to performance in designing practical investigations, the results from pupils' attempts to plan an experiment to see if black covered wire is a better conductor of electricity then white covered wire were analysed. The outcomes, generally, are disappointingly poor and equally so for boys and girls. They are not differentiated in favour of pupils who had used the Matsapha materials. Just over half of the students in each group offer an (invalid or valid) experimental design, but a quarter find it adequate to merely justify an expected outcome without any experimental verification. Similarly, Knamiller *et al.* (1995) found for a sample of Tanzanian science teachers that around two-thirds responded to an experimental design task as if it were a knowledge question.

However, the very small percentage of students indicating the need to control extraneous variables, and paying attention to increased accuracy of measurements was higher in the experimental group than in the comparison group. This can be considered a modest success of the Matsapha materials. Whereas almost half of both the low-achieving and high-achieving students in the comparison group suggest a valid investigative design, this percentage is slightly higher in the high-achievers in the experimental group but dramatically lower in the low achievers in this group.

The Matsapha materials have helped the abler students in formulating valid investigative designs, but confused the less able ones. The technological approach also encouraged some greater attention to procedural aspects of practical work. One in every four students in the experimental and comparison groups respond to an experimental design task as if it were a knowledge question.

(b) students' attitude to learning activities for science with a technological approach

Almost 300 students from 8 classes from urban, peri-urban and rural schools were taught through the Matsapha materials, and returned a questionnaire after completing each of the units. The first part of the questionnaire listed thirteen types of learning activities included in the Matsapha materials, and asked students to identify the three activities they most liked, with an explanation of their choices. Some of these activities are specific to the Matsapha materials, others are common to many other materials. The second part of the questionnaire asked them to select the three least liked activities from the same list. This section was completed by only about half of the sample for each unit, but these numbers are still considered large enough to provide a representative sample.

The frequencies with which various activities were ranked amongst the three most, or three least, liked learning activities were counted. The reasons provided by students were allocated to one of a small number of coding categories for each activity. The completeness and distinctiveness of these coding categories, and their application, were validated by peer review.

Detailed findings are reported in Dlamini *et al.* (1995). For each of the 13 activities, the percentages of students who included the activity amongst their most liked ones have been transformed into grades. The first four ranked activities are graded as *high,* the bottom four ranked activities as *low,* and the remainder as *medium.* The same has been done for the percentage of students including each activity amongst their three least liked ones. Combining these grades and taking cognisance of the fact that a low grade may mean indifference towards the activity concerned, a classification of student perceptions of each learning activity can be made. This is reflected in Table 7 below.

Table 7 Classification of student perceptions of learning activities.

activity	most liked grade	least liked grade	student perception
c. group discussions	high (53%)	high (28%)	contentious
k. reading stories	high (45%)	medium (22%)	mainly liked
g. listening to the teacher explain	high (43%)	medium (21%)	mainly liked
a. doing a play	high (29%)	medium (20%)	mainly liked
1. recording experimental results	medium (15%)	low (18%)	slightly liked
m. solving practical problems	medium (15%)	medium (21%)	mixed
d. group practical work with	low (11%)	low (12%)	indifferent

instructions			
b. explaining what happens around us	low (11%)	low (14%)	indifferent
j. observing practical demonstration by teacher	low (6%)	low (17%)	indifferent
e. identifying science in everyday life	low (4%)	low (18%)	indifferent
h. planning an experiment	medium (17%)	high (26%)	mainly disliked
f. labelling diagrams	medium (17%)	high (33%)	mainly disliked
n. writing reports	low (10%)	high (33%)	disliked

Table 7 shows that *group discussion* is a contentious activity since it ranks highly amongst the most popular **and** amongst the least popular activities. Positive views of *group discussion* are based on its perceived benefit in terms of gains of understanding from sharing and refining ideas. Those who do not favour this activity do so because of problems with social interaction in the groups. Group discussion is encouraged in the Matsapha materials, as it is in the SWISP. However, in SWISP little teacher guidance is provided and these activities can be more easily avoided than in the Matsapha materials.

Group discussion as a learning activity is contentious as strong positive and negative opinions are expressed by a large proportion of the sample. In order to optimise the beneficial effects of group discussions, teachers need to provide clear guidelines on group interaction, i.e. that all members should have a chance to bring in their suggestions, and that a group does not necessarily have to reach a consensus but may report two or more opinions.

Students mainly liked *listening to the teacher explain* (they attract only a medium percentage of respondents who include them as least popular) with a very strong emphasis on the perceived knowledge gains. A large proportion of the students suggested that the teacher provided focus. Apparently, both boys and girls in this cluster are more concerned with identifying what needs to be learnt rather than gaining understanding of the concepts to be learnt. The explanation of the teacher provides confidence to students that what they learn is the 'right thing', both in terms of the correct science and the required science for the examination. By contrast, students who identified *listening to the teacher explain* amongst the least liked activities mostly reasoned that they gained a better understanding of the science by 'doing' rather than 'listening'.

Listening to the teacher explain is mainly liked as a learning activity. Teacher exposition is played down in the Matsapha materials. It seems, however, imperative that at the end of contextualised lessons a summary of the scientific concepts to be learnt is provided which the teacher can reiterate and which will provide the students with confidence that the 'right thing' to learn has been identified for them. The final application phase of most Matsapha lessons when the initial every day incidence is re-visited provides an opportunity for consolidating the understanding of this science.

On balance, *reading stories* and *doing plays* are mainly liked. Reasons for the popularity of both activities focus primarily on their perceived support of increased understanding of the science ideas, and less so because the interesting contexts they provide. A considerably smaller proportion classifies these learning activities amongst the least liked activities. Their reasons usually also focus on knowledge acquisition and indicate that the contextualised stories or plays do not provide anything students need to know, or provide only knowledge students already know!

The stories and plays as lesson introductions are specific to the Matsapha materials and represent ways of contextualising the science content which are apparently well appreciated. *Reading the stories* and *doing plays* as learning activities are, however, primarily appreciated because they help the understanding of science concepts, rather than link these concepts to everyday life.

A separate observational classroom study into student interest and lesson participation related to the contextualised aspects of the Matsapha lessons (Lubben et al., forthcoming) shows several students indicating surprise that everyday instances may be combined with classroom science. Student interest in learning about the science behind the common applications was raised by three types of contexts. The classroom observations show that the choice of interest-generating contexts does not need to be limited to those from students' own experiences, but includes also historical applications, such as traditional ways of storing maize to prevent germination, and covers advanced technological applications such as the use of oxygen masks used during aeroplane emergencies are appropriate. Students need to be able to relate to the context but familiarity is not a requirement. Interest increases for contexts in which students are perceived to be able to offer expertise themselves, such as the workings of electric hot combs, or welding procedures. Contexts which are considered contentious, such as the causes of lightning, or traditional eating or sexual habits also create interest.

Observational studies have shown that student interest in learning about the science behind the common applications was raised by the following three types of contexts: (i) contexts students can relate to including familiar experiences but also historical and high-tech industrial settings students have heard about (ii) contexts where students perceive themselves (or their peers) to have expert knowledge; (iii) contexts students perceive as contentious

The findings show that contextualisation has a potential for encouraging student participation in science lessons, although students frequently remain focused on suggesting solutions for the incidence, rather than providing a (scientific or non-scientific) explanation for their suggestions. However, a high pupil commitment to positions taken in contextualised discussion has been noted.

Several instances are reported where increased participation provides the opportunity for teachers to identify misconceptions amongst their students. If teachers are able to make use of these diagnostic possibilities they can more easily build new learning on existing understanding. However, the findings indicate that, in order to make optimal use of the potential of contextualised lessons, teaching styles need to move away from the traditional teacher-centred approach.

Data show that contextualised materials stimulate student participation and provide the opportunity of identifying student misconceptions. If the full range of benefits of contextualised lesson material is to be realised, in-service activities to introduce such materials must not only aim at familiarising teachers with the

curriculum but also at promoting acceptance and adoption of a learner-centred approach to teaching.

Contextualised teaching approaches such as in the Matsapha materials depend on the provision of large amounts of information, either as a story, a play, a role play, tabular data, or otherwise. In each case, limited proficiency of second language learners provides additional hurdles, and requires extra time to digest the information given, and to respond to it. Although many teachers blamed the slow pace of their teaching on the requirement of student participation in many of the learning activities, the lack of language mastery equally caused delays.

Teaching with contextualised materials is slow, because of its novelty, the requirement of student participation and the high demand on processing verbal information. The latter is likely to remain a lasting reason for a slow teaching pace with such resources.

Returning to the appreciation of the various learning activities (Table 7 above), *labelling diagrams* and *writing reports* are two activities which are clearly disliked. A high percentage of students include them amongst their least liked activities, and only a medium or low percentage lists them as their most liked activities. The reasons provided confirm in both cases that students are uneasy about committing themselves to definite answers such as are required in both of these activities. This type of reaction is in line with the student demand for authoritative teacher exposition of 'truths'. Neither of these activities is specific to the Matsapha materials, although they both feature.

Learning activities such as *labelling diagrams* and *writing reports* are clearly disliked as both activities are perceived to be closely related with assessment.

There are four activities about which students do not have firm opinions. These are listed as popular or unpopular by a low percentage of students. Amongst these are activities such as *explaining what happens around us* and *identifying science in everyday life,* both expressions of the application nature of the Matsapha materials. Although the research instrument was field-tested, there is some anecdotal evidence that a number of respondents were unclear about these descriptors, which may explain, in part, why very few firm opinions about these activities have been submitted. Further research is needed.

The responses to the investigative nature of the Matsapha materials may be found in the appreciation, or lack of it, of activities such as *solving practical problems* and *planning an experiment.* A discussion of student perception of these activities follows below after the consideration of the gender aspects.

Although students value learning activities representing the contextualised nature of the materials, they are indifferent to those activities emphasising the application aspects, and, by and large, dislike the investigative activities. In the latter case gender differences seem to have an influence.

Thus far we have looked at perceptions on the various learning activities for the whole sample. However, it is of interest to identify the activities which are particularly attractive to girls. The responses have been separated according to gender and are presented in Table 8 for most liked and least liked activities.

Table 8 Frequency of learning activities listed amongst three most liked and least liked by gender, (percentages in brackets)

activity	amongst 3 **most liked**				amongst 3 **least liked**			
	after AL unit		**after EL unit**		**after AL unit**		**after EL unit**	
	boys (n=127)	**girls (n=144)**	**boys (n=134)**	**girls (n=157)**	**boys (n=55)**	**girls (n=82)**	**boys (n=59)**	**girls (n=87)**
a. doing a play	32 (25%)	47 (33%)	29 (22%)	**55** (35%)	16 (29%)	14 (17%)	14 (24%)	12 (14%)
b explaining what happens around us	16 (13%)	16 (11%)	14 (10%)	16 (10%)	8 (15%)	9 (11%)	8 (14%)	16 (18%)
c. group discussions	63 (50%)	78 (54%)	76 (57%)	80 (51%)	15 (27%)	23 (28%)	17 (29%)	25 (29%)
d group practical work with instructions	10 (8%)	17 (12%)	17 (13%)	20 (13%)	7 (13%)	10 (12%)	5 (8%)	12 (14%)

e. identifying science in everyday life	7 (6%)	7 (5%)	7 (5%)	3 (2%)	12 (22%)	14 (17%)	12 (20%)	14 (16%)
f. labelling diagrams	**33 (26%)**	22 (15%)	17 (13%)	23 (15%)	18 (33%)	26 (32%)	20 (34%)	29 (33%)
g. listening to the teacher explain	50 (39%)	58 (40%)	61 (46%)	70 (45%)	10 (18%)	19 (23%)	15 (25%)	15 (17%)
h planning an experiment	25 (20%)	23 (16%)	**31 (23%)**	19 (12%)	15 (27%)	16 (20%)	13 (22%)	29 (33%)
j. observing practical demonstration by teacher	10 (8%)	4 (3%)	11 (8%)	9 (6%)	4 (7%)	**20 (24%)**	10 (17%)	13 (15%)
k. reading stories	65 (51%)	75 (52%)	39 (29%)	**72 (46%)**	13 (24%)	17 (21%)	15 (25%)	19 (22%)
l. recording experimental results	21 (17%)	19 (13%)	24 (18%)	21 (13%)	12 (22%)	16 (20%)	10 (17%)	13 (15%)

m. solving practical problems	9 (7%)	19 (13%)	**33 (25%)**	23 (15%)	16 (29%)	18 (22%)	12 (20%)	13 (15%)
n. writing reports	8 (6%)	12 (8%)	12 (9%)	26 (17%)	17 (31%)	30 (37%)	16 (27%)	30 (34%)
TOTAL:	127	144	134	157	55	82	59	87

The first five columns of Table 8 present the most liked activities for boys and girls. This shows that girls were strikingly consistent in their preferences across the two units. Girls seem to like learning activities regardless of the topic being taught. The few cases of significant differences in the popularity of the various activities in the different units are due mainly to the boys. *Labelling diagrams* and *reading stories* were significantly less popular in the Electricity unit than in the Air and Life unit because they were less liked by the boys. *Planning an experiment* is liked more in the Electricity unit than in the Air and Life unit because of the greater enthusiasm of the boys. Only the significantly higher level of popularity of *writing reports* in the Electricity unit is due to its greater support from girls.

The responses for each unit may now be compared for boys and girls separately. In the responses to the activities in the Air and Life unit, only one gender difference was significant. More boys than girls listed *labelling diagrams* amongst their favoured activities (chi-squared value 4.78). However, for the activities in the Electricity unit, the responses showed four significant gender differences. The high support of girls for *doing a play* and *reading stories* was common to both units, but the popularity of these activities amongst the boys was significantly lower for the Electricity unit (chi-squared values 6.31 and 8.60 respectively) than the Air and Life unit. Instead, significantly more boys listed *planning an experiment* and *solving practical problems* amongst their most favoured activities for this unit (chi-squared values 6.18 and 4.63 respectively).

In the results for the least liked activities, only one gender difference is significant. In the responses about the Air and Life unit, a significantly lower percentage of boys than girls included *practical demonstration by the teacher* amongst their least liked activities (chi-squared value 6.68).

Girls were very consistent in their preferred learning activities across the two units. Any differences in the appreciation of learning activities between the two units are due to a difference in popularity with the boys. Consequently, learning activities highly favoured by girls, such as *doing a play* and *reading stories,* may be considered as topic independent. These activities could be emphasised specifically to make science learning more attractive to girls and, in particular, offer an avenue to maintain girls' interest in 'boys' topics such as circuit electricity.

The investigation aspect is represented by activities such as *planning an experiment* and *solving practical problems.* There, a significant gender difference is found in the preferred activities in the Electricity unit. Both *planning an experiment* and *solving practical problems* are favoured significantly more by boys than by girls. Overall, we may conclude that the investigative nature of the Matsapha materials obtains a mixed response. While mainly disliked, it is most liked by boys studying Electricity. This seems to indicate that, in general, students are unwilling to take responsibility for independent thinking and acting unless the context is challenging enough to overcome this hesitance.

A significant gender difference is found in the popularity of investigative work, but only in one unit (Electricity). Boys respond more positively than girls to such learning activities *as planning an experiment* and *solving practical problems.* This is a fundamental change, away from the normal request for 'spoon feeding'. Additional research is needed to identify investigative contexts which are appealing to Swazi girls.

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7. Other outcomes

The research project was directed at in-service strategies for introducing teachers to science teaching materials with a technological approach, and at the learning effects of students who have used learning materials for science with such an approach. However, the research required a first phase during which such learning and teaching materials were constructed. From the outset, the project intended to support the generation of materials by teachers with a wide range of experience and training. The materials development phase has been used as a research opportunity to monitor critical aspects of the materials development process contributing to the professional growth of the teachers involved. Professional growth is seen here as: (i) the change in teachers' self perception as curriculum designers; (ii) the change in professional self confidence; (iii) the growth in the teachers' science knowledge and understanding and; (iv) the extent of the acceptance of the three characteristics of the innovation. A detailed report is provided in Lubben *et al.* (1995a).

Our evidence supports the view of Naidoo and Samuels (1993) that given appropriate opportunities, teachers in Southern Africa can be active and creative participants in curriculum development, although the vast majority do not initially see themselves as materials producers. Furthermore, the production and presentation of lesson materials by the teachers, their behaviour over the workshops, their dialogue with workshop facilitators, their written feedback and their behaviour during the pilot stage all support the notion that considerable professional growth took place through their involvement with curriculum development. We consider that this growth was an indication of curriculum empowerment.

Successful strategies to increase teachers' self-perception as curriculum creators include the following: * Invitations to materials writing workshops need to be made to individuals who have a loyalty to the facilitators for other reasons; * In contrast to the lesson content, a general structure and a format for recording the lessons may be suggested by the facilitators for adoption; * Brainstorming at the workshop beginning is unproductive unless contributions are solicited as light-hearted anecdotes or stories; * Participants work productively in pairs on different lessons with frequent plenary reporting to a whole group of a maximum of 12 colleagues;

* Opportunities to develop a 'group terminology or language' need to be exploited in order to foster group identity;

* After drafting workshops for several of these groups, participating teachers need to be given some weeks of ordinary classroom teaching before an induction workshop to combine the work of these teacher groups;

* The induction workshop should use the collated draft lessons with limited expert-editing but with attractive and professional lay-out;

* During the induction workshop peer-teaching of teachers' own and others' draft lessons needs to be included;

* Trialling provides many suggestions for improvement of the materials. These ideas can not be collected through asking teachers to keep diaries or make notes. It is more effective to arrange and record regular discussion sessions for colleagues who have taught with the same materials.

There are indications that professional development will only result from participation in materials writing if a teacher accepts the role of creating, in addition to absorbing. If not, no materials will be produced, but also any ready-made innovations are less likely to be implemented. Pre-service teacher training programmes should, therefore, emphasise and practice the role of the teacher as curriculum constructor.

Our experience in this project is that the objectives of a curriculum innovation are readily accepted by teachers if they are perceived as helping students to understand science concepts more easily. Because the idea of starting from local contexts was seen to do this, it was incorporated into lesson materials and used in teaching. The objectives relating to the application of science knowledge beyond the classroom, while accepted in principle, was not seen as a priority for inclusion in the taught curriculum. Objectives related to the development of investigative strategies were less readily accepted initially but after class trials accepted with great enthusiasm by a few of the teacher-developers.

Thus far we have described the process for the whole group of 12 teacher-developers. It would be useful, however, to identify clusters of teachers within the sample showing similar patterns of adoption of the objectives of the curriculum innovation and, if possible, relate these to the development of their self-perception as curriculum developers during the materials writing process. Because of the small number of teachers, the identification of any patterns can only be speculative but will be useful as hypotheses for further research.

Three clusters may be distinguished. Firstly, a 'no-ignition' group of teachers have from the start a very low perception of themselves as materials developers, and persistently do not see a role for themselves in the process. They require the curriculum to be delivered to them. Participation in a materials development process was irrelevant to them. They show very little adoption of curriculum innovations, and when adopted do so uncritically. They are (here) male diploma holders at schools with limited resources and poor results, with both short and medium teaching experience. They radiate a feeling of stagnation in the teaching profession.

A second group of teachers, the 'perpetuators', perceive themselves more as materials designers from the start. They develop their creative and reflective abilities in this area during the process of lesson materials writing, paying a lot of attention to detail of usage of appropriate language and sequence. When asked, they attempt the new context-led teaching strategy successfully. They do not, however, adopt the innovative teaching strategies, and even explicitly argue against inviting students' opinions, insisting on the teacher's role as an authoritative expert. During pilot teaching they reluctantly refrain from immediately judging student speculations. They are (here) very experienced female diploma holders at well-managed schools with usually excellent examination results. These teachers are self-confident active professionals.

A last group of teachers, the 'adopters', have slightly more intuitive affinity with the objectives of the innovation. At the start they have a lower self-perception as curriculum designer than the 'perpetuators'. They develop and accept a view on teachers as curriculum developers and, subsequently, adopt the objectives of the curriculum innovation. Their implementation of the new teaching approach is close to the intended curriculum. They are (here) a mixture of male and female degree holders and diploma holders with and without professional training. All have taught between 2 and 4 years. They are assertive and willing to debate their opinions with peers.

The data suggest that further research is needed into the possibility

The data suggest that further research is needed into the possibility of facilitating adoption of specific new curriculum objectives through training teachers in the skills of creating and evaluating teaching materials. This has implications for pre- service teacher training and curriculum induction programmes in centralised education systems where teachers are familiarised with new national curricula and the accompanying ready-made materials. The strategy of practising the creation of *any* part of the new lesson materials may well facilitate the adoption of (usually) externally created prescribed innovations.

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8. Impacts

Apart from the direct impact on teachers and students involved with the research, within Swaziland the project has influenced the current National Examinations through intensive contact with the examiner. The findings of the project have contributed to the current discussion in the National Science Panel towards revision of the secondary science curriculum. A project researcher has been invited to present the philosophy of the science with a technological approach, the lesson structure and the experiences with the use of the Matsapha lessons at the first of a series of workshops for the relevant committee of the Science Panel. At further meetings, the strategies used for teacher involvement in the development of the materials, and the INSET strategies used for the induction of new teachers will be shared.

Resulting from the current project, the Swaziland Ministry of Education has suggested the initiation of a pilot project to develop contextualised lesson materials specifically focused on linking science teaching with Swazi industry. They wish then to include both formal large and small scale industrial technologies and informal and indigenous production methods. The results of such a project will feed into the current curriculum review. A project document based on experiences with the development of the Matsapha materials drawing on expertise from the Universities of Swaziland, York and Cape Coast (Ghana) has been submitted and funding obtained from the Rockefeller Foundation, Nairobi. Thus, the outcomes of the current project on the technological approach to science will be consolidated.

The Matsapha materials are currently being used as exemplar materials in pre-service and in-service teacher training programmes, and for post-graduate programmes for curriculum developers at several institutions in Southern Africa, e.g. the Universities of Botswana, Dares-Salaam, Durban-Westville, Lesotho, Swaziland, Western-Cape and Zambia, and several NGO in-service programmes within South Africa. Some institutions in Europe which focus on science education in Southern Africa, such as the University of Leeds and the Free University of Amsterdam have shown a similar interest.

Within South Africa several NGO groups involved in teacher in-service, such as the Centre for Advancement of Mathematics and Science Education (CASME) at the University of Natal, and those involved in teacher-based materials development such as the Science Curriculum Initiative for South Africa (SCISA) based at the University of Durban-Westville have utilised strategies shown to be effective in this research project. In addition, contacts have been established with material development groups in South America and the Caribbean who intend using approaches to materials development and in-service which have been tested in this project.

The project has also influenced an EU-feasibility study into regional collaboration within Southern Africa in the area of science education, in that the method of teacher development through materials production has gained considerable prominence.

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9. Recommendations on future action

INSET programmes aiming to familiarise teachers with new curriculum materials need to take note of the following points.

(i) Pre-workshop tasks are only effective in a culture of ownership of INSET activities by the INSET participants. Such a culture may take a considerable time to develop.

(ii) Peer teaching sessions help teachers to obtain an overview of the structure of new materials and to gain familiarity with the range of the learning activities. Ample time must be given to peer teaching sessions. Teachers perceive the benefit of more than one opportunity to peer teach.

(iii) A blend of INSET activities is needed for effective adoption and implementation of a technological approach to science teaching. Making participants responsible for conducting peer teaching sessions especially facilitates implementation of the context-led nature of the resource materials. Insight into the teaching strategies aimed at the application of science concepts is aided best through reflective group discussions led by the INSET provider. The appreciation of investigative teaching activities is encouraged by hands-on practical activities with post-event discussions.

(iv) Involving in INSET a practising teacher who has experience with the materials to be introduced is useful for building professional confidence, but is not essential.

(v) In-school support after an INSET workshop is seen as very valuable for both teachers and students, but is difficult to arrange. Teachers show no resistance to classroom observation or team-teaching if the fear of a 'teaching practice situation' can be dispelled.

(vi) A brain storming session on everyday contexts for teaching science topics as part of the INSET programme is insufficient to help transfer of the context-led teaching approach. The role of participants' self perception as materials developers in facilitating transfer of a new teaching approach needs to be further explored.

(vii) For experienced or inexperienced non-specialist science teachers, the INSET programme developed to introduce materials with a technological approach to science needs to be preceded by a programme to enhance subject knowledge and understanding. Where subject content is weak the new approach causes insecurity and results in rejection of the approach.

(viii) INSET needs to focus on the positive effects a new approach may have on the learning of students, rather than on a teacher's own teaching. Such an emphasis may avoid the rejection of the innovation by beginning, untrained science specialists. Equally, such an emphasis encourages novice and experienced trained science specialists to consider the classroom implications of the new approach.

A longitudinal evaluation method can successfully be used to link specific activities in an INSET programme to teacher perceptions of a curriculum innovation, their relevant concerns and their classroom behaviour.

Concerning the student response to learning science through a technological approach the following points are of note.

(i) The attainment of science concepts for the first cohort of students using the new materials is of a lower level than expected. In order to judge the teaching approach fairly, however, such attainment is better measured with subsequent cohorts after teachers have familiarised themselves more intimately with the approach.

(ii) Further research needs to document the (untaught) 'natural' investigative abilities of students to solve problems practically. The Matsapha materials form a starting point for the introduction of teaching strategies to improve such abilities. However, teacher insight in this area needs to be improved considerably.

(iii) Context-led materials for science with a technological approach can be used to increase student interest and participation, particularly if they can relate to a (familiar or unfamiliar) context, see themselves as experts in the area, or perceive the context as contentious. Further such materials are needed.

(iv) In order to optimise the beneficial effects of group discussion, teachers need to provide guidelines to make clear that all members should offer suggestions, and that no consensus is required when reporting.

(v) Context related learning activities such as *reading stories* and *doing plays* need to be used more frequently in science classrooms to increase student understanding, and specifically to maintain the interest of girls in science.

(vi) It needs to be accepted that context-led learning requires a large amount of processing of verbal information and, therefore, will proceed at a slower pace than other methods. (vii) Appropriate investigative activities can be used to break through the student preference for 'spoon feeding'. However, suitable investigative tasks motivating to African girls still need to be identified.

At a local level (Swaziland), the dissemination of the Matsapha materials needs to be continued and consolidated so that the experience can contribute directly to the current review of the national science curriculum.

It is recommended that a further research project be formulated and implemented to test the tentative model resulting from this project of training teachers in the skills of creating and evaluating teaching materials as a way of facilitating their adoption of specific new curriculum objectives. This follow-up research project needs to further explore methodologies of measuring teacher professional development as materials creators, and relate specific stages of development to a progression in the acceptance of the approaches underpinning a particular curriculum innovation. The results of such a study will have implications for curriculum induction programmes in centralised education systems. Although current trends are to move away from curriculum change at national level, towards allowing a decentralised regionalised adaptation of general national curriculum guidelines, teachers in developing countries will still need to work towards value congruence with the underlying curriculum ideas.

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