TEACHER SUPPORT MATERIALS AS A CATALYST FOR SCIENCE CURRICULUM IMPLEMENTATION IN NAMIBIA

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For Meerte

Chapter 1
Introduction and overview of the MaC study

*This chapter introduces the MaC study (**M**aterials **a**s **C**atalyst) carried out in Namibia in the period 1994-1997, in the context of educational reforms after independence in 1990. It provides a short introduction to the context of the study, focusing on curriculum reforms as well as the assistance given by the INSTANT Project to curriculum implementation, professional development of teachers and materials development (section 1.2). Section 1.3 outlines the aims of the MaC study, while section 1.4 provides an overall view of the research design of the study. A more detailed elaboration of the issues raised in this short introductory chapter follows in the subsequent chapters. Section 1.5 provides an overview of these chapters.*

1.1 Introduction

Betty Andima is a teacher in the Ondangwa region in Namibia at the northern border with Angola. She teaches science in a school that is built of corrugated iron sheets which makes temperatures soar during the hot season. When it rains, the noise on the roof makes communication in the classroom almost impossible. Just like many other teachers in Namibia she is very excited about the new science curriculum the Ministry is implementing. She attends all the workshops organised by the INSTANT Project, either in her region or in the capital, Windhoek, about 750 km away from her school.

At one such workshop for science teachers in Windhoek, the facilitator had asked Betty's group to present - in a microteaching session, with participants as students - part of a science lesson on the structure of the atom to the workshop. During the lesson students needed to be actively involved in an activity illustrating the different particles in the atom, and the role each one of them plays. She liked the idea a lot, but she had never heard of protons and '… what were the other particles called again?'

Betty's group worked for some time on the preparation of the lesson activity. Members of the group taught Betty about neutrons and electrons, and what they were doing in the atom. The lesson, presented by Betty, gave students an overview of the various particles. On the basis of that information, students were asked to show 'an atom in action' using fellow students as subatomic particles. Students went outside to the playground to demonstrate their understanding of the structure of the atom. Before long, several smaller, speedy students, as electrons, were whizzing around the nucleus made up of heavier students as protons and neutrons.

When Betty returned to her school, she couldn't wait to introduce this activity to her students.

Aaron Musonda is a Grade 8 science teacher in Katima Mulilo in the Caprivi region in the north-east of Namibia. He has attended a number of workshops organised by the INSTANT Project on the implementation of the new science curriculum. He likes the hands-on approach of the new curriculum, even though he has little experience with it in the classroom. His school has never had any science equipment to do experiments, which is why Aaron is so happy when he receives a science kit from the project. His headmaster is equally excited about the science kit when Aaron returns from the workshop.

When the project visits Aaron in his school about six weeks later, there is no sign of the science kit. Aaron says that it is in the headmaster's office. There is no storeroom and he has no cupboard in his classroom. The headmaster proudly shows the science kit in the cardboard box. Some of the items are used; much is still in the original wrapping paper. 'Now that the kit is in my office, I can also keep an eye on it', says the headmaster. 'Even when the inspector comes, I can show him that at this school we know how to treat government property'.

Mary Kambinda was quietly minding her own business in front of the staff room of her school. She had been teaching from the early morning. While the other teachers were in class she enjoyed her short break sitting in the pleasant winter morning sun. Just for a while she thought that teaching was not so bad after all. Although she was trained as a primary school teacher, she had ended up teaching in the junior secondary section of the school, teaching English language and geography. It was not easy but she was coping well. Life seemed to be smiling on her …

By the dust in the distance she could tell the headmaster was coming back from the education office in town. As he got out of the car he seemed rather agitated. He came straight to Mary. What seemed like a pleasant morning was about to turn into a small nightmare. 'Mr Likando is transferred to another school. You'll have to take the Grade 10 science class' the headmaster said without greeting her. 'I can't leave them without a teacher until their exams'. Mary was stunned, but still managed to utter that she wasn't a science teacher. The headmaster wouldn't listen. 'You start on Monday, you have the whole weekend to prepare'.

These events took place in Namibia during the early phase of the implementation of the educational reforms after independence in 1990. These, and many others of this kind, serve as an illustration of the state of the education system in Namibia just after independence, showing great optimism and courage, and ready to take on the job. But it is also an illustration of an education system with a teaching force that was for a large part under-qualified, short-staffed, and taking on a content-laden curriculum with a poorly developed organisational infrastructure.

The MaC study (**M**aterials **a**s **C**atalyst) took place in the early stages of major educational reforms introduced in Namibia in the years following independence. It focused on the design and evaluation of support materials for science teachers in junior secondary schools, comprising the first three grades in secondary school.

The study investigates the characteristics of materials that adequately support teachers in their efforts to implement the new science curriculum in the classroom - often in very difficult circumstances. Furthermore, the study aims to contribute to methodological guidelines for the development of such materials.

1.2 Context of study

1.2.1 Educational reform after independence

At independence, Namibia inherited an education system from its colonial power, South Africa that was organised along ethnic lines. A total of 11 separate educational authorities had been established, leading to duplication of activities and wasted resources. After independence, a major restructuring exercise resulted in the establishment of one Ministry of Education and Culture (Angula & Grant Lewis, 1997).

The disparity between the different population groups in Namibia prior to independence is well documented (Angula & Grant Lewis, 1997; Cohen, 1994). After independence in 1990, the ministry introduced a massive reform programme to address the problems caused by the pre-independence education system. Not surprisingly, in the years immediately after independence, problems in the system remained. The teaching force in general -but especially for the sciences and mathematics at secondary level -was largely unqualified (Cohen, 1994). With increased access as one of the major goals of educational reform (MEC, 1993b), the system expanded rapidly. The increase in the number of students caused a shortage of qualified teachers, which was often remedied temporarily by employing unqualified teachers and students who had just finished senior secondary school.

School infrastructure was generally not very well developed and basic equipment for practical work was lacking in most schools. Schools in rural areas were often very isolated and lacked access to modern means of communication (telephone and fax). Large distances between schools and from schools to the regional centres further contributed to this isolation.

Teacher education was reformed with the development of the Basic Education Teacher Diploma (BETD) programme (Dahlström, 1995; MEC, 1992b), catering to grades 1-7 (primary school) and grades 8-10 (junior secondary school). Another cornerstone of the reform was a major curriculum reform in both primary and secondary education. The Ministry of Education and Culture developed and introduced the new curriculum over a very short time-span (MEC, 1992).

1.2.2 Curriculum reform

The Ministry of Education and Culture in Namibia started a major programme of curriculum reform soon after independence. English became the new language of instruction, which had previously been Afrikaans before independence. Educational development was based on the philosophy of Education for All; its goals being reflected in the keywords: access, equity, quality, and democracy.

Towards the end of 1990, new subject syllabi were hastily developed for all subjects in junior secondary education (Grade 8-Grade 10). Within the course of six weeks, an ad-hoc committee consisting of mainly advisory teachers developed a new science curriculum. Similar activities happened in other subjects. At a later stage, curriculum development became much more structured with the establishment of the National Institute of Educational Development in 1992. Policy and curriculum documents (cf. MEC 1993b, MBEC, 1995) demonstrated the very high aspirations of Namibia's curriculum reform. Teaching and learning were to take place in a learner-centred way. Subject matter had to be presented in a way related to the students' daily life experience, with group work and practical work advocated as a normal part of the classroom practice. Assessment would be based partly on course work with students taking greater responsibility for their own and each others learning. Although such curriculum goals are in line with internationally current standards in education, they seemed far removed from the curriculum teachers in Namibia were used to, and even further removed from what was happening in Namibian classrooms.

1.2.3 Curriculum implementation

In Namibia, teachers had warmly welcomed the educational changes introduced immediately after independence, as these were seen as a much desired break with the pre-independence educational system and curriculum. However, the translation of curriculum goals and objectives into classroom activities and behaviours left much to be desired (van den Akker et al., 1994). In addition, teacher qualification and experience, poor school infrastructure, lack of equipment for practical work, large classes and overloaded time tables all contributed to a low level of success for implementation. Moreover, teachers at schools in rural areas were often operating in isolation due to poor means of communication and long distances between schools and to the regional education centre. The lack of opportunity to discuss progress on a regular basis with colleagues also contributed to the very limited success of implementation. The ministry's monitoring exercises at the end of every Grade level, not surprisingly, observed very little evidence of the reform goals manifested in the classrooms (MEC, 1991a, 1993a).

Implementation of the new science and mathematics curriculum in Namibia started in 1991. The phased implementation began in the first grade of the junior secondary level (Grade 8) and continued upward one grade level every year - Grade 9 in 1992 and so on. English language, mathematics and science were declared priority areas in both primary and secondary education. The Ministry of Education and Culture also started in 1991 with large scale professional development projects, mostly externally funded, focusing on teachers in junior secondary schools to support the implementation of the new curricula in those areas. One such project was the INSTANT Project.

Chapter 2 further elaborates the issues related to science curriculum reform in Namibia after independence.

1.2.4 The INSTANT Project

The INSTANT (IN-Service Training and Assistance for Namibian Teachers) Project, was funded by the European Union (EU) and was administered first by the Vrije Universiteit Amsterdam (VUA), and later by VUA in cooperation with the British Council of the UK (INSTANT, 1991). In the years following independence, the INSTANT Project provided support for the implementation of the new curriculum to teachers in secondary schools and upper primary schools. The multitude of activities carried out during the six years the project was active (1991-1997) can be categorised into three broad interrelated components (Ottevanger & Benschop, 1995):
1. in-service training activities (workshops, cluster meetings),
2. building an infrastructure for sustainable professional development,
3. materials development.

The project's goals were initially directed towards teachers, with emphasis on raising awareness for the new curriculum, its goals and its manifestation in the classroom, and provision of training in new teaching methods for active learning. The emphasis gradually shifted to the development of a sustainable regional infrastructure for supporting teachers by training local staff as professional developers.

Materials development activities of the INSTANT Project focused primarily on teacher guides and exemplary lessons. The project was interested in formative evaluation methods to improve the quality of these materials, especially with a view to assisting teachers with problems in the initial phase of the implementation of the new curriculum in their classrooms.

The MaC study uses the term *teacher support materials* to refer to materials that can assist teachers in their efforts to implement curriculum reforms in their classrooms. These materials take the form of exemplary lesson materials. Earlier studies had shown that teacher support materials designed from an implementation perspective, and guided by formative evaluation, can be very effective. Such materials proved to be especially useful in the vulnerable initial phase of the implementation when teachers are faced with new problems and when positive initial experiences can provide the necessary impetus for a successful implementation (cf. van den Akker, 1988; Voogt, 1993; Keursten, 1994).

1.3 Aims of the MaC study

The INSTANT Project considered it essential to develop materials that would function as a support to teachers whose task it was to implement the new curriculum in the classroom. This needed to happen in circumstances often far from ideal.

The central aim of the MaC study, conducted in the framework of the INSTANT Project, was to optimise the quality of the materials that support teachers in the implementation of the new science curriculum in the classroom. Furthermore, the study aimed to contribute to methodological guidelines for the development of such materials (in Namibia and possibly in other countries in the region).

If materials were to serve as an effective support to teachers for the implementation of the new curriculum, an important early question was what such materials should look like? More specifically, the question was formulated as:

What are the characteristics of materials that adequately support teachers in the initial implementation of science curriculum innovation in the classroom?

In the Namibian context, teacher support materials would have a number of distinct functions. The materials needed to support teachers with their orientation on new subject matter and new teaching methods, as well as lend guidance in preparation of the lessons, thus providing teachers with successful experiences in the vulnerable initial phase of the implementation of the curriculum. The latter can also contribute to a change in attitude towards, and belief in, the new teaching methodology advocated in the new curriculum.

1.4 Research approach

1.4.1 Development research

The MaC study followed a development research approach. Development research is carried out 'to inform the decision making process during the design, production and implementation ... of an educational program with the purpose of improving the program' (Walker, 1992, p. 111). In the domain of curriculum, van den Akker and Plomp (1993) argue that development research serves two purposes:

- optimising the development of prototypical products (curriculum documents and materials), including empirical evidence of their quality;
- generating methodological directions for the design and evaluation of such products.

Van den Akker et al. (1994) explored some of the problems hindering a smooth implementation of the curriculum innovations in the classrooms of Namibia. They argued that much in the education system in Namibia was subject to change and implementation conditions were generally unfavourable. Development research guiding the development of programmes and curriculum materials could, in such a situation, take away some of the uncertainties of the development process and would provide learning experiences for all those involved in such a process. In addition to the two purposes mentioned in the previous paragraph, possible additional results were considered important, including reaching a better understanding of the local implementation conditions and the problems teachers are facing, and increased expertise and professional growth of the various participants in the development process.

1.4.2 Overall research design

The research design of the MaC study consists of three related stages. The *first* stage, the *front-end analysis* in the MaC study includes a context analysis and problem analysis (described in chapter 2), and a review of the relevant literature on curriculum implementation in the Southern Africa region (chapter 3). This stage resulted in preliminary design specifications for curriculum materials in the Namibian context. The three stages are elaborated in detail in chapter 4.

The *second* stage (described in chapter 5) consists of a preliminary study on the design and evaluation of teacher support materials for *Scientific Processes*, a Grade 8 topic (first year secondary school) in the new science curriculum for junior secondary schools in Namibia. This topic was chosen because of its innovative character in terms of student involvement, and the way in which it deals with the topic in the setting of the local community. It focuses on a number of basic science process skills such as measuring, observing, classifying, as well as presenting and recording results. Besides finding provisional answers to the general research question, the pilot study also aimed at finding answers to a number of questions of a more practical and methodological nature. 'Does a development research approach work in the often deeply entrenched practices of developing countries?' and 'Are the methods used and the various instruments developed to gather data practical and easy to use?' were typical questions at this stage.

The *third* stage (described in chapter 6) forms the main part of the study. It focused on the design and formative evaluation of teacher support materials for a completely new topic in the science curriculum for Grade 10 (final year of junior secondary education), called *Materials*. This topic was included in the syllabus to provide hands-on opportunities for students in rural areas where schools often had very little or no science equipment. It deals with local practices such as making bricks and thatching roofs, and requires students to test - in a hands-on manner - the strength of bricks and insulating properties of different roofing materials used in their local communities.

The *Materials* topic provided the teachers with both opportunities and challenges and was chosen as the subject for the MaC study because of its highly innovative character in the Namibian context. It seemed far removed from the usual, more academic science topics, such as *particle theory*, *periodic* *table*, and *radioactivity*. Teachers had indicated at in-service training workshops that they anticipated having problems with the specific subject matter. Moreover, many teachers, especially those in the former Black schools, had little experience with hands-on activities, and were worried about doing group work, especially when activities were to be conducted outside the classroom.

The research design in this stage included several cycles of design and formative evaluation to make the original prototype iterate towards a more definite product.

In the early years after independence, the Namibian education system was in a state of continuous development. Local implications of Ministry policy could not always be foreseen at the time the research design was established. The organisation of the various activities was problematic as communication with teachers at schools in the regions was often very difficult. In this situation, flexibility could be achieved by conducting several smaller field tests in different iterations that could respond to local circumstances at fairly short notice. The design of the study emerged over time (compare the notion of emergent design by Smith, 1990).

1.5 When reading the following chapters

Chapter 2 describes the context of education in Namibia, reflecting on the years immediately preceding independence, as well as the situation after independence in 1990. Chapter 3 reviews the literature on science curriculum development and teacher development in developing countries, with specific attention to Southern Africa. Chapter 4 outlines the research design of the MaC study.

The next chapters describe the set-up, results, and conclusions of two studies on the design and evaluation of teacher support materials. Chapter 5 reports on the preliminary study on the design of materials for a Grade 8 topic of the science curriculum, called *Scientific Processes*. Chapter 6 details the try-out, user appraisal and field test on the design and formative evaluation of the teacher support materials for a Grade 10 topic called *Materials*. Chapter 7 discusses the outcomes of the study.

Chapter 2
Education in Namibia

This chapter reviews education in Namibia, both during the years leading up to independence in 1990, as well as in the early years following independence. It focuses on the inadequate provision of education for the non-White population groups before independence (section 2.2), and how the results of this could still be felt after independence, despite the major reform programmes at all levels of the Ministry of Education (section 2.3). Section 2.4 provides a summary view of the context in which the implementation of the new science curriculum took place following independence. Section 2.5 looks at the implications the context has had for the execution of the MaC study.

2.1 Namibia - the country

Namibia is situated in the southwestern part of Africa and covers an area of 824,000 square kilometres, roughly the size of Germany and France combined (see figure 2.1). This sparsely populated country is home to two major deserts, the Namib Desert in the west and the Kalahari in the east. The north and northeast of the country are largely tropical with plenty of rain and lush vegetation. A semi-arid plateau of about 1800 meter altitude separates the two deserts. The capital Windhoek is on this plateau. Inhabitants of Namibia comprise several different ethnic groups.

In 1991 Namibia had a population of 1,512,000. There are 10 ethnic groups, the largest of which are the Owambos, Damaras and Hereros. The population growth rate was 3.0 % per annum between 1981 and 1991. In 1991 about 60 % of the population is under the age of 30 years. See figure 2.2 for further details.

Figure 2.1: Namibia

Namibia became a German colony by 1880. Before then, its people lived in relative anonymity, protected by the uninviting Namib Desert (after which it is named) along its Atlantic coastline. The German occupation was marked by expropriation of land and cattle resulting in bitter and uneven struggles with the local Herero and Nama inhabitants. Under General von Trotta, 60 % of the central and southern population of Namibia was exterminated. After the First World War, at the Versailles Peace Conference, the League of Nations gave the mandate to govern Namibia to the king of Great Britain, who delegated it to South Africa. Under the mandate agreement South Africa was 'to promote to the utmost the material and moral well-being and the social progress of the inhabitants of the territory' (UNIN, 1986). Instead, South Africa annexed the territory and effectively made it its fifth province. In 1964, after the Odendaal commission, the so-called Bantustans ('homelands') were introduced, similar to those in South Africa.

The Country	Area of 824,296 km^2. Consists mainly of desert, semi-desert and savannah. Some areas are suitable for agriculture and cattle breeding. Independent since 21 March 1990.
Capital city	Windhoek, 158609 inhabitants in 1991 (census).
Government	Namibia is a republic. Sam Nujoma is the president since March 1989. Parliament consists of the National Assembly (72 members) and the National Council (26 members). The South West African People's Organisation (SWAPO) is the biggest political party.
The People	Namibia has a population of 1.73 million (1998), 2.1 inhabitant per km^2. There are 10 ethnic groups, the largest of which are the Owambos, Damaras and Hereros. The population is densest in the North along the border with Angola and on the central plateau, where the rainfall is heaviest. The population growth rate was 2.5 %per annum between 1994 and 2000. Life expectancy (1997) is 53 years (females), 51.8 years (males)
Religion	Christian (80-90%), of which at least 50% Lutheran; traditional religions (10-20%).
Languages	English (official language), Oshivambo, Herero, Nama. German. Afrikaans is the common language of most of the population .
Education	In 1991, there were 395,786 people aged 6-16 in Namibia, and 330,451 (83 %) of this age group were enrolled at school. The country has four teacher training colleges, Colleges of Education, in Katima Mulilo, Ongwediva, Rundu and Windhoek, a Polytechnic and a university, University of Namibia.
Literacy	About 80 % is literate (1997). Adult literacy programmes are a government priority.
Economy	The economy is mineral based. Minerals provide 60 % of all export earning. The balance is covered by fishing, tourism, agriculture and manufactured goods. More than half of the population depend on (largely subsistence) agriculture for its livelihood. Economic growth is 2.6 % (1998); 1.4% (1997). In 1992 the GDP was US $ 2.6 billion, or US $ 1,778 per capita (US $ 3.2 billion or US $ 1,994 in 1998). The wealthiest 5 % (mainly Whites) receive 70 % of the country's GDP, while the poorest 55 % receive only 3 %.
Monetary unit	In 1993 Namibia introduced its own currency, the Namibian dollar. The dollar is on par with the South African Rand. Namibia is part of the South African Customs Union.

Figure 2.2: Namibia Profile

After UN supervised elections in 1989, Namibia gained independence in 1990 after a long and bloody struggle. Most of the people live in the rural areas with an estimated 27 % of the population living in towns. Windhoek is the capital with about 160,000 inhabitants (1991 census), but this has continued to increase at quite a high rate as, similar to other developing countries in Africa and elsewhere around the world, people flock to the urban centres in search for employment. Figure 2.2 gives a short profile of Namibia.

Namibia's education system at independence showed an enormous disparity between Whites on the one hand, and the Black and Coloured population groups on the other. In the years following independence, the Ministry of Education and Culture undertook a major reorganisation and reconstruction exercise, affecting all parts of the education system, in order to address the imbalances of its colonial past. It is difficult to view the education system in Namibia at the time without considering the education system prior to independence. Section 2.2 therefore briefly discusses developments in the education system in the years leading up to independence in 1990. Subsequently, section 2.3 looks at the development of the education system after independence.

2.2 Education system in the years leading up to independence

Before independence, education in Namibia was administered as part of the South African system of Bantu education. The disparity between education for Whites and for other ethnic groups before independence is well documented (cf. Angula & Grant Lewis, 1997; Cohen, 1994; UNIN, 1986). For example, at independence the Administration for Whites spent eight times as much per pupil as the Owambo Administration (Angula & Grant Lewis, 1997). The disparity between population groups was not only in spending per pupil. Non-white groups were also disadvantaged in access to schooling beyond the lower primary grades, quality and relevancy of curricula, teacher training opportunities and teacher qualifications, as well as the distribution of subject advisors, inspectors and qualified teachers (Angula & Grant Lewis, 1997; Cohen,1994).

Analysis of available data on teachers in the system (cf. Cohen, 1994) indicates that in 1988 the student to teacher ratio was 12:1 for White schools and 34:1 for Black schools. Many teachers in the north of the country had gone into exile, while the private sector lured many of the better qualified teachers away from education by paying them better salaries. The government tried to stem this exodus by increasing teachers' salaries and by bringing the salary scales of Black and Coloured teachers in line with those of their colleagues in the White population group.

The shortage of teachers resulted in very unfavourable student to teacher ratios. There was only one qualified teacher for every 200 to 300 students in the Ondangwa and Rundu regions. Supply of teachers in mathematics, science and English was even more problematic with student to teacher ratios for these subjects being even more dramatic than those given above. Teacher training courses were generally of low standard and focused mostly on subject knowledge and at primary school level. Little effort had been made to provide serious professional development to practising teachers.

Not surprisingly, relatively few students in the Black and Coloured population groups passed the final senior secondary school examinations. Very few black students took science and mathematics at senior secondary level. In the Katima Mulilo region the first students to write the school-leaving examination for physical science was in 1990 (11 in total). In the Ondangwa region only 120 students sat in that year for physical science. In comparison, 509 students in the Windhoek region wrote school-leaving exam for physical science in 1991. Pass rate for the subject were much lower in the northern regions compared to the Windhoek region (18% in Ondangwa, 0% in Katima Mulilo region, 50% in Windhoek region for the Standard Grade examination (Dimmendaal & Van der Laan (1993).

For the White population group, primary teacher training took place at the Windhoek Teacher Training College. Secondary teacher training was organised at South African universities. For the other population groups, the Academy (multiracial institute for tertiary education) offered teacher training (primary and secondary) at its main campus in Windhoek. Teacher education for teachers in the northern regions took place at satellite campuses of the Academy in Ongwediva, Katima Mulilo and Rundu (Cohen, 1994). At these campuses, only primary teacher training, the Education Certificate Primary (ECP), was offered. This programme focused mostly on subject content at the expense of teaching methodology.

There were no serious professional development activities for teachers before independence. Moreover, the International Conference on Teacher Education for Namibia in Lusaka in 1989 acknowledged that the subject knowledge of the poorly qualified teachers (about 30% of the teaching force) was 'inadequate to serve as a basis for further in-service training for subject advisors to build on' (Cohen, 1994, p. 166).

As a result, the vicious circle was kept intact at all levels whereby low intake in teacher training courses led to a low standard output in terms of numbers and quality of teachers. This dearth of qualified teachers in turn resulted in poor teaching performance and poor student results, where the cycle of failure begins again. This was the situation Namibia inherited at independence.

2.3 Educational policy after independence

At independence, Namibia inherited an educational system that was fragmented along ethnic and racial lines. The SWAPO government began to implement a process of reconstruction of the educational system with a single ministry responsible for educational administration and provision of education for the whole of Namibia. The Ministry of Education and Culture (MEC) had its headquarters in Windhoek and six regional education offices in the regions Katima Mulilo, Rundu, Ondangwa, Khorixas, Windhoek and Keetmanshoop (see figure 2.3). This reconstruction process alone represented considerable change since prior to independence educational administration was divided amongst eleven separate and largely autonomous educational regions.

As is true of most change processes, this transition was neither easy nor painless. Angula and Grant Lewis (1997) describe tension between affirmative action and protection of existing appointments, problems with the relocation of competent school leaders into management and government bureaucracy, finances and budgetary policies as constraints in the process of reconstruction.

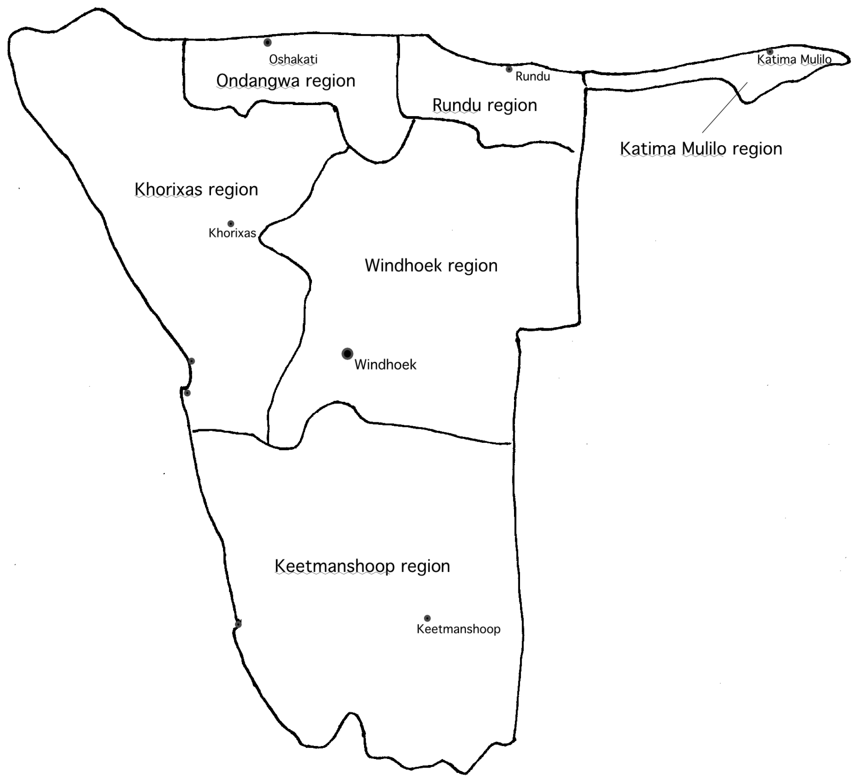


Figure 2.3: Educational regions of Namibia

Sections 2.3.1-2.3.8 highlight important features of the new educational system put in place after independence, focusing on Basic Education and Senior Secondary Education, schools, student enrolment, supply of teachers, teacher qualifications, curriculum development and implementation, and the professional development of teachers.

2.3.1 Education for All

Before independence, education was the privilege of a few. Although the majority of Black children went to school, only seldom did their education extend beyond a few years of primary school. After independence, the new Namibian constitution stipulated that all persons have the right to education, and that primary education was now compulsory and free of charge.

The Jomtien Conference on 'Education for All' in Thailand, acknowledging the fundamental right to basic education for all children, took place in the same month that Namibia gained independence. 'Education for All' also became a major goal of Education in Namibia. The Ministry's policy document 'Toward Education for All' (MEC, 1993b) formulated four goals to remedy many of the imbalances of the past and to reach a situation in which (basic) education would be available for all citizens: *access, equity, quality and democracy.*

- Access - education is to provide the majority of Namibia's citizens with basic skills of reading, writing, numeracy, and the socio-cultural processes and cultural phenomena.
- Equity - to overcome the legacy of the past. Equity in results is formulated as a long-term objective.
- Quality - of teachers, teacher training and (physical) facilities, de-emphasising the examination results as the supreme indicator of success and a learner-centred teaching approach to cater for students from varying backgrounds.
- Democracy - as a 'central purpose' of the education system, implying a broad participation by all those involved in making decisions on educational matters.

2.3.2 Basic Education

The Ministry of Education and Culture developed a ten-year Basic Education Programme, consisting of a four-year lower primary phase (Grades 1-4), a three-year upper primary phase (Grades 5-7) and a three junior secondary phase (Grades 8-10). Initially, the Ministry had considered a nine year curriculum, with a two year junior secondary phase (Craelius, 1994), but this was abandoned in favour of a ten-year Basic Education programme.

An external examination at the end of Grade 7 is an evaluation point for entry of students into junior secondary level. Basic Education is concluded with a national examination at the end of Grade 10 (see figure 2.4). The results of this examination are used as an entry criterion for admitting students into the senior secondary level. A further two years of senior secondary education (Grades 11 and 12) follows Basic Education.

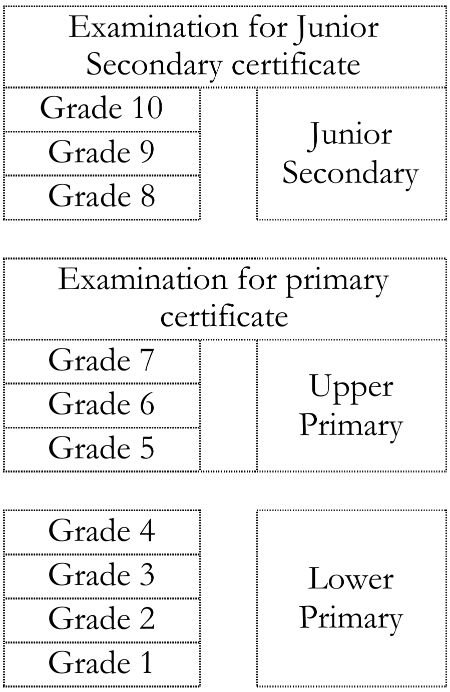


Figure 2.4: Structure of Basic Education

The National Institute for Educational Development (NIED) has the responsibility for the development of the Basic Education curriculum. NIED was established in 1991 and has the responsibility for curriculum development, materials design, pre-service and in-service teacher training programmes, as well as research and development. The goals of the Basic Education reflect the spirit of a new nation and its policy of national reconciliation: promotion of national unity, liberty, justice, democracy and human rights, respect for oneself and others, their cultures and religions. In addition to the goals listed above (reading, writing, numeracy, and the socio-cultural processes and cultural phenomena), the goals encompass the domains of personal development (foster morality, integrity, and responsibility) and work ethics (perseverance, reliability, and accountability).

Competencies are used to describe what students should be able to do as outcome of teaching and learning (MBEC, 1996b). Life skills competencies describe what students must develop in preparation for adult life (e.g. investigating, communicating). Basic Skills competencies describe what students should have achieved at the end of a lesson or lessons (e.g. " ... demonstrate at least one method of filtering dirty water..."). Competencies help teachers to evaluate the student achievement as well as the effectiveness of their own teaching methods. Assessment, specified separately for the lower primary, upper primary and junior secondary levels, consists of both informal and formal continuous assessment and well as end-of-year examinations (junior secondary only).

Learner-centred teaching and learning

The Ministry’s policy document ‘Toward Education for All’ (MEC, 1993b) also gives a clear direction of the desired teaching methods to be employed in the Basic Education programmes. Teaching should take the interests of students as its starting point. The emphasis needs to be on quality and on meaningful learning. The approach to teaching and learning needs to be *learner-centred,* which in the view of the Ministry meant that:

- the starting point is the students' existing knowledge, skills, interests and understanding;
- natural curiosity of students, and eagerness to learn, needs to be nourished by challenging tasks;

- students should be empowered to think for themselves and take responsibility for their own and one another's learning and development;
- students should be involved as partners in, rather than receivers of, education.

2.3.3 Senior Secondary Education

The senior secondary phase covers Grades 11 and 12. Admission into this phase is based on results in the Grade 10 examination. Initially, few schools had the facilities and the qualifications of teachers needed to offer this phase. However, the system is under pressure to provide more spaces for additional students. The International General Certificate of Secondary Education (IGCSE) and its higher (advanced) version, HIGCSE, from the University of Cambridge Local Examinations Syndicate (UCLES) were adopted as the curriculum for senior secondary education (Grade 11 and 12). The Ministry of Education and Culture put the Pilot Curriculum for Formal Senior Secondary Education (MEC, 1993c) in place in 1993. The 1994 cohort of students was the first taking this curriculum. The HIGCSE was specifically developed for Namibia in consultation with South African universities. The HIGCSE syllabi were offered to students who wanted to register with South African universities upon successful completion of secondary school. Although the HIGCSE curriculum was purposely made for Namibia, the science syllabus contained surprisingly little, if any, local Namibian content.

2.3.4 Professional development of teachers

To remedy the legacy of the past with regards to poorly qualified teachers, resulting in poor teaching and poor student achievement, the Ministry of Education & Culture gave high priority to teacher education, both in-service training and pre-service training (MEC, 1992a; MEC, 1993b; Swarts, 1997). In the five-year development plan on in-service teacher training (MEC, 1991b), the Ministry outlined a multi-pronged approach to the improvement of teaching in Namibia. A pivotal role was designated for teacher support through the establishment of regional teacher resource centres and the training of facilitators. Resource centres would be multi-functional, facilitating upgrading and in-service training for teachers at all levels, and providing schools and local communities with access to library facilities, distance education and adult education. All regions established teacher-resource centres in the regional capitals with smaller sub-centres in other strategic places in the regions.

A key aspect in the execution of the in-service training programmes was the concept of 'training the trainers'. The Ministry used a programme of workshops for in-service teacher training. National workshops were set up for training regional trainers, and to develop programmes for regional in-service training conducted by these regional trainers (cf. INSTANT Project, 1992). The Ministry received support from various donor countries for the execution of the in-service training programmes. A variety of projects attached to the Ministry or operating as NGOs assisted the Ministry carrying out the in-service training programmes. The INSTANT Project provided support for the implementation of the new science and mathematics curriculum to teachers in secondary schools and upper primary schools.

In addition to such in-service training programmes, many teachers were also involved in more formal upgrading courses. In a survey carried out in September - December 1991 among 418 teachers in 124 schools in all six educational regions (Auala, 1993), 48 % of the teachers indicated that they were involved in a part-time study. Sixty-two percent of these were studying for their Standard 10 (Grade 12) school-leaving certificate. A 1995 survey (INSTANT, 1996) indicated that 38% of all unqualified secondary science and mathematics teachers had been or were still involved in upgrading courses.

2.3.5 Supply of teachers

The Basic Education Teacher Diploma programme (BETD) prepares teachers of all subjects for teaching Basic Education classes (Grade 1-10). The programme started in 1993 and is offered at four Colleges of Education in Katima Mulilo, Rundu, Ondangwa, and Windhoek. A total of 1548 student teachers were enrolled in 1995 in the four colleges, including 35 students following the Higher Diploma in Education (HDE) course at Windhoek College of Education, which was phased out at the end of 1995. (Dahlström, 1995).

An in-service BETD has been developed and started with the help from UNESCO with an enrolment of 500 teachers. In 1995, Windhoek College of Education was still offering in-service upgrading courses, which started before independence, to 318 teachers.

At school level, volunteer teachers from Nigeria and Egypt, and through volunteer organisations like US Peace Corps and the UK Volunteer Services Overseas (VSO), compensated to some extent for the acute needs for teachers in junior and senior secondary schools.

2.3.6 Teacher qualifications and teacher experience

Teacher training

A large-scale study carried out by the INSTANT Project together with the Vrije Universiteit in Amsterdam (INSTANT Project, 1996) provides data on qualifications of Namibian mathematics and science teachers. About 9 % of the teaching force in Namibia is made up of foreign teachers.

According to the study, 68 % of the Namibian science teachers at secondary level have completed a teacher-training programme, 26 % have a Standard 10 (Grade 12) or lower only, while 6% of the teachers have completed academic training beyond secondary school, but no teacher training. Of the junior secondary science teachers who have a teaching qualification, 77 % completed a teacher-training programme for primary school, 9% for junior secondary level, and 14% for senior secondary. The 1995 statistics of the Ministry of Education and Culture (EMIS, 1996a) shows a comparable 72% teachers (of the 777 physical science teachers) who possesses a formal teaching qualification, but not necessarily in a science subject.

Primary trained teachers have typically moved up, often in and through Combined Schools (primary and one or two years of junior secondary level in one school), and have ended up teaching science or mathematics at junior secondary schools. This phenomenon is especially prevalent in the northern regions Katima Mulilo, Rundu and Ondangwa.

While teachers' qualifications are presented here for Namibia as a whole, there are considerable regional differences. Teachers in the Windhoek, Keetmanshoop and Khorixas regions are generally better qualified than their colleagues in the three northern regions (EMIS, 1996b). Teachers with a teacher qualification in the northern regions usually have a primary teacher training (about 90 %) and very little exposure to subject content beyond junior secondary school. In contrast, 50-60 % of teachers with a qualification in the southern regions (Windhoek, Keetmanshoop and Khorixas) have followed a training programme geared towards senior secondary school.

Subject knowledge

Mathematics and science teachers often have an academic qualification in a non-mathematics or non-science subject. The INSTANT Project study therefore explored the subject knowledge of teachers of life science, physical science and mathematics. It took the position that a teacher needs to have enjoyed schooling three years beyond the level they are teaching themselves. E.g. a teacher of a Grade 9 class should have completed no less than Grade 12 in that specific subject. Using this criterion, the study showed that 88 % of the physical science teachers did not have sufficient subject knowledge for the level at which they were teaching. These figures were 83% and 93% for mathematics and life science respectively.

Teachers at the senior secondary level are much better qualified than their counterparts at the junior secondary level. Sixty-four percent of the teachers at this level have completed a teacher-training programme for senior secondary education. About 50 % of the teachers have sufficient subject knowledge to teach at this level, according to the same guidelines as outlined for the junior secondary teachers. This is so for all science subjects and mathematics.

Teacher experience

Of the mathematics and science teachers in junior secondary schools, 23% have teaching experience of more than 11 years. About 40 % have 5 years of experience or less.

2.3.7 Schools and students

Schools

According to statistics from the Ministry of Education and Culture (EMIS, 1996b), there were a total of 1372 schools in Namibia in 1995: 925 primary schools, 337 so-called combined schools (offering both primary and junior secondary phase) and 110 secondary schools. These schools had a total of 13856 classrooms, of which 9157 are permanent (brick, mortar), 1489 pre-fabricated, 229 hired and 2981 traditional (21.5%). Traditional structures are almost exclusively found in the northern regions of the country. In 1995, schools reported a total of 313 laboratories (one of which is in a traditional structure). About two thirds of these are in schools in the regions Windhoek, Khorixas and Keetmanshoop. Many schools have very limited sanitary facilities, especially in the north of the country, only 36 % of the schools in the Rundu region have running water. Only few schools in the southern regions are without water. Between 5 and 20 % of the schools in the northern regions have a telephone installed, while most schools in the Windhoek and Keetmanshoop regions do have this facility. Similar differences exist between the north and the rest of the country for connection to mains electricity and the availability of staff housing.

Students

Enrolment of students has increased from 420,980 in 1991 to 471,653 in 1995. This represents an annual growth rate of 2.9% (EMIS, 1996a). In comparison, 367,626 students were registered in 1988 (Cohen, 1994). The enrolment in Grade 1 in 1991 was 88,693, but has since come down to 65,258 (1995), and to the same enrolment as just before independence when 67,809 students were enrolled in Grade 1 in 1988 (Cohen, 1994). This is because the backlog of students who did not go to school before independence has gradually been cleared. Enrolment peaked with 474,343 students in 1994 when the Walvis Bay rejoined Namibia (see figure 2.5). In comparison, enrolment figures for 1988 indicate 67,809 students in Grade 1 (Cohen, 1994). In 1995, 88.9 % of the children between the ages of 6-16 were at school (EMIS, 1996b). For the ages of 7-13 (ideal ages for students of grade 1-7) 95.2 % was at school in 1995. At the time, the Ministry was well on its way to meeting the goal of 'Education for All'.

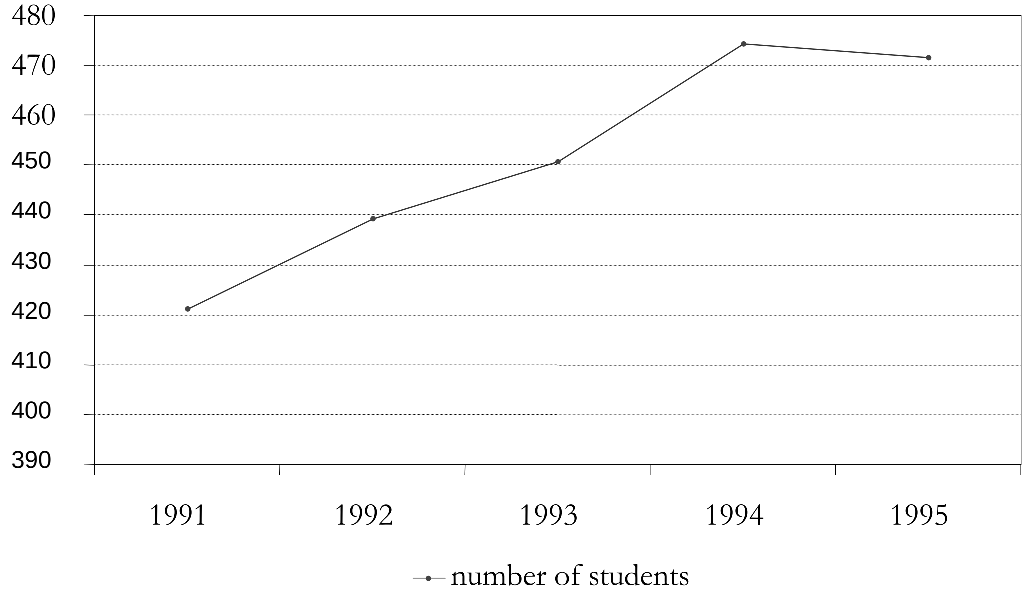


Figure 2.5: Enrolment figures in thousands (1991 - 1995) (EMIS, 1996)

Progression figures through Grades 1-7 indicate that the female students are promoted at a higher rate than male students (e.g. Grade 1 to 2: male 67.3%; female 70.0%). Male students are promoted at a higher rate, however, in the secondary grades (e.g. Grade 9 to 10: male 80.7%; female 75.9 %).

Dropout rates and repetition rates at primary level are highest in Grade 1 (7.2% and 24.2% respectively), and are much higher in the northern regions (up to 10%) than in the southern regions (2.5-3.9%). High dropout rates in Grade 10 are caused by the fact that promotion to senior secondary education is not automatic, but based on Grade 10 external examination results.

2.3.8 Curriculum development

The Ministry of Education and Culture in 1990 took steps to phase out the existing pre-independence curriculum and to replace it with a newly developed alternative. Curriculum development immediately after independence was carried out in a hasty and ad-hoc manner and with very short timelines. For example, a small committee consisting of advisory teachers developed the original physical science syllabus in late 1990 in a period of 4 weeks. Due to a shift in thinking, the length of Basic Education was extended from nine years to ten years. The committee was further charged with expanding the syllabus to cover an additional year, which took them another two weeks. Though perhaps far from ideal, this process sent a strong signal that the Ministry was serious about its educational reforms.

Since then, the curriculum development process in Namibia has been formalised. The National Institute for Educational Development (NIED) is responsible for curriculum development and materials design (as well as for pre-service and in-service teacher training programmes, research and development). Curriculum development is now guided by the Pilot Curriculum Guide for Formal Basic Education (MBEC, 1996a). It provides instructions for Working Groups, which draw up the specific subject syllabi. These typically consist of NIED subject specialists, regional advisory teachers and experienced teachers. Drafts of syllabi are usually sent to the regional offices for comments from regional advisory teachers, school principals, and teachers.

In spite of NIED's efforts to achieve inclusiveness in the development of curriculum, development was carried out by small groups of devoted personnel who unfortunately had to do their work in isolation. Much of the process was carried out by foreign advisors who made up for the lack of locally available expertise in this domain. Their involvement inevitably led to curricula different from the 'traditional' ones. The minister of education at the time describes how foreign advisors were also used as a neutralising buffer against conservative forces in the Ministry (Angula & Grant Lewis, 1997). Original subject syllabi were often unrealistic due to the extremely short time available for their development (Alberts, 1997). Revisions introduced in 1995, however, (four years after the original syllabi) addressed much of the criticism expressed by teachers during in-service training activities. Revisions were made especially in those subjects for which continued in-service training was offered with the assistance of foreign donor input, including science and mathematics (INSTANT Project and Life Science Project).

2.4 Context for curriculum implementation

The ambitious reform programme put in place by the Ministry of Education and Culture addressed many of the imbalances that existed before independence. The Ministry exerted great effort in seeking international assistance for its implementation. During 1991 (and the years thereafter), programmes with several foreign countries had been initiated or extended. The Ministry's annual report of 1991 (MEC, 1992a) lists no less than 26 countries, European Community, and UN organisations like UNDP and UNESCO with which cooperation agreements had been undertaken. Many of the projects initiated under these programmes were directly involved with the implementation of the new curriculum in the schools. In the domain of science and mathematics, Florida State University, Life Science Project, and the INSTANT Project provided assistance to the Ministry in its implementation efforts. Foreign advisers in these projects worked along with staff of the regional advisory services providing additional human resources and skills, as well as providing training for the often poorly prepared advisory teachers.

Many of the pre-independence problems continued to hamper the implementation of the new curriculum in the early years following independence:

- The teaching force in general, but mathematics and science teachers at junior secondary schools in particular, remained largely unqualified. There were too few (qualified) teachers for the expanding number of students.
- Poor school infrastructure and lack of basic equipment remained problematic, especially at junior secondary level, and in the domain of science teaching.
- The long distances between the capital Windhoek and the northern regions continued to be an obstacle for proper communication with schools and regional centres and for the organisation of a regional teacher support structure.

Additional problems resulting from the multilevel educational reforms existed. Many teachers felt they could lose control over their students with the abolishment of corporal punishment creating a sense of insecurity among the teaching force. The shift from Afrikaans to English as the medium of instruction was problematic for both teachers and students.

The supportive attitude of teachers towards the new curriculum did not necessarily mean that implementation was automatic and easy. Teachers often felt uneasy with the new content and the new teaching methodologies. Not surprisingly, monitoring exercises at the end of the first and second year of implementation of the junior secondary school curriculum (MEC, 1991a; 1993a) showed little manifestation of the desired changes in teaching methodologies--such as active participation of students and execution of meaningful tasks which build upon existing student experiences. Similar observations were made by Mkandawire (1993) who studied teacher practices in 330 classes in Namibia after independence. He found that in more than 90% of the classes, teachers relied on 'chalk and talk' teaching methods.

2.5 Implications for the study

The unfavourable conditions highlighted in this chapter obviously hampered implementation of the new curriculum. In-service training programmes for teachers offered by the INSTANT Project - although rated as very successful by teachers, school headmasters, advisory teachers and the Ministry (MEC, 1995a) - had a limited immediate effect in the classroom (cf. MEC, 1991, 1993a). The INSTANT Project felt that:

- more information was required about the actual implementation conditions in the schools;
- a more careful and sensitive approach to curriculum implementation was needed, which takes the poor qualifications of teachers into account;
- more specific guidelines were required to support teachers who implemented the new curriculum in very difficult circumstances.

Materials development had been one of the INSTANT Project's central tasks since its inception in 1991. The project used the materials as organising elements in workshops and as a support to teachers implementing the curriculum in the classroom. The project realised that the success of implementation of the science curriculum in the classroom was limited despite its massive efforts and those of other projects. It realised that a more careful analysis of and anticipation on the implementation context was necessary. The consequence of this for the materials development was that the project wondered what quality materials in the Namibian context should look like, and how they should be developed. The project felt that a kind of development research approach seemed promising for both the product quality as well as for its collective learning about design, evaluation and implementation methods (van den Akker et al., 1994).

The resulting MaC study, carried out in the framework of the INSTANT Project, adopted such a development research approach. It asked the question: 'What are the characteristics of teacher support materials that would provide adequate support for teachers implementing the new science curriculum in the unfavourable context of the Namibian classroom?'

Chapter 3
Science curriculum reform and teacher development in developing countries

This chapter presents the theoretical framework for the MaC study. It uses relevant literature to discuss science curriculum development and implementation (section 3.2) and teacher development (3.4), and relations between them, both in general and in the context of developing countries in Southern Africa (section 3.3). Results of relevant empirical studies in the domain of science education reforms in developing countries are analysed for their implications for the formulation of the problem and for the design of the study (section 3.5).

3.1 Introduction

Implementation of curriculum reforms in the classroom has been problematic ever since the beginning of modern curriculum development. Goodlad, Tye and Klein (1979) and many others have reported on the discrepancies between intentions of the developers and the way the innovations were implemented in the classroom. Cuban (1992) provides us with many examples of curriculum innovations in North America since the last century, all of which appear to have made very little impact on life in the classroom. "*In maths, science and social studies, the refrain is the same: 'frontal' teaching, traditional instruction, teacher-centred instruction, conventional teaching - the value-charged code words differ, but the habits of teachers persist.*" (Cuban, 1992, p. 236). While the above examples reflect on situations in the developed world, similar observations have been made in context of curriculum reform in developing countries (cf. Snyder & Ramatsui, 1990). In the next section, central concepts and interrelationships between these concepts are discussed, culminating in a conceptual framework for curriculum implementation and teacher development.

3.2 Curriculum implementation

3.2.1 Concept of curriculum

Curriculum can be defined as 'the content and purpose of an educational programme together with their organization' (Walker, 1990, p. 5). The simple working definition used here is that of curriculum as 'a plan for learning' (van den Akker, 1998). The curriculum includes 'some notions of where the traveller is going, how the traveller might get there, and what life might be like not only on arrival but also along the way' (Marsh & Willis, 1995, p. 9).

For the discussion on curriculum development and implementation it is often helpful to look at the different representations of the curriculum as formulated by Goodlad et al. (1979) and adapted by van den Akker (1988). These include:

- *ideal* curriculum – as it lives in the minds of the designers;
- *formal* curriculum – the written curriculum documents;
- *perceived* curriculum – as the curriculum is perceived, especially by teachers;
- *operational* curriculum – how the curriculum manifests itself in the classroom;
- *experiential* curriculum – how the curriculum is experienced by students in the classroom;
- *attained* curriculum – as manifested through learning outcomes.

The ideal curriculum and formal curriculum together are also called *intended* curriculum. Likewise, the perceived curriculum and operational curriculum together, are also called *implemented* curriculum.

Curriculum evaluation studies tend to compare the ideal (or formal) curriculum with the experiential and attained curriculum, without having clear insight in the intermediate curriculum stages. Realising that '*educational change depends on what teachers do and think – it's as simple and complex as that*' (Fullan, 1991, p. 117), the importance of the intermediate stages of the curriculum becomes evident. Rather than taking note of the formal curriculum and exploring the learning outcomes, (and often concluding that implementation of the curriculum has failed), it is important to explore the intermediate levels of the curriculum. 'What do teachers think about the curriculum? How is it put in action in the classroom? How do students experience the curriculum in the classroom?' are typical questions that can guide studies on curriculum implementation.

3.2.2 Concept of curriculum implementation

Curriculum implementation can be defined as the translation of the intended curriculum into the operational curriculum - the classroom practices. Implementation is often presented as the second phase in a three-phase model of change: initiation, implementation, continuation (or institutionalisation) (Fullan, 1991).

Initiation is the process that leads up to the change, in which the decision of whether or not to proceed with implementation takes place. In developing countries, change programmes are often initiated centrally, driven by political factors, and by external agencies, especially if these agencies also provide funding for such change programmes.

Implementation is the process of putting a change programme into practice.

Continuation/Institutionalisation of a change programme means that the change becomes part of the normal practice of an institute or a school. Institutionalisation requires successful implementation and needs to be planned for and given attention during the implementation phase.

These three phases usually take place in chronological order, even though there is considerable interaction and overlap between the different phases. The transition from one phase to the next is often ill defined, especially moving from the implementation phase to institutionalisation. Implementation is considered to be the biggest hurdle in the change process (Fullan, 1991). Initiation and institutionalisation are not less important, but initiation without implementation has little value, and implementation without institutionalisation will result in little long-term effect of a proposed change. Implementation of change can happen in a variety of ways. Section 3.2.3 takes a closer look at implementation in practice.

3.2.3 Perspectives on curriculum implementaion

Three different perspectives on curriculum implementation exist in the literature (Snyder, Bolin & Zumwalt, 1992):

- *fidelity*: the curriculum is implemented in accordance with the original intentions of the developers;
- *mutual adaptation*: adaptations of the intended curriculum are made by curriculum developers and practitioners;
- *enactment:* teachers and students use curriculum materials as tools to construct their own curriculum in the classroom.

The fidelity perspective is often implied in large-scale curriculum innovations, like in the context of centralised curriculum development systems in African countries. Teachers are supposed to implement the curriculum in line with the developers' intentions. Mutual adaptation suggests a process of negotiation between the developers and teachers in schools. Enactment usually takes place when small groups of teachers and students set out to develop and implement their own curriculum, rather than implement an external curriculum.

Mutual adaptation has emerged as a preferred model by many (Snyder, Bolin & Zumwalt, 1992) because it provides opportunities for adjustments in the curriculum in view of changing needs, interests, beliefs, local circumstances and skills of participants and organisations. The mutual adaptation perspective (as well as the enactment perspective) puts the curriculum development process at the centre of the implementation efforts. Projects reviewed by Snyder et al. (1992) and deemed to have been successfully implemented were characterised by a process of mutual adaptation. However, there are also undesirable scenarios of mutual adaptation (Clandinin & Connelly, 1992) such as non-implementation and cooptation. Non-implementation is simply when nothing changes, such as when the process of interaction between a project and an institute breaks down. Cooptation describes the situation in which the innovation is changed to the extent that project design conforms to the usual way of operation at the institution.

3.2.4 Conceptual framework

Curriculum implementation is the translation of the intended curriculum into the operational curriculum. As pointed out in the previous paragraph, there is usually not a direct translation, but more a negotiation between innovation projects on one side, and schools and teachers on the other. Fullan (1991) has indicated that several factors influence implementation of a new curriculum. One of these factors concerns the characteristics of the change (the need, clarity, complexity as well as the quality of the innovation). Besides curriculum issues, there are several other factors that influence implementation. Especially important among these factors are the degree to which districts and the community support the educational reforms. Furthermore, the stimulating role of the principal as well as the organisational structure of the school is of utmost importance in the implementation (Joyce & Showers, 1990). Teachers play *the* central role in the implementation of the new curriculum in the classroom, in developed as well as in developing countries (Montero-Sieburth, 1992). Their beliefs, their views on new roles, but also the level of training, expertise and professionalism, are important factors in the implementation. Finally, there is an important role for external projects and teacher support groups (Joyce & Showers, 1988).

These issues are incorporated in a framework for curriculum implementation as presented in figure 3.1. It presents implementation as the link between the intentions of the developers on the one hand, and the effects of the curriculum on the other.

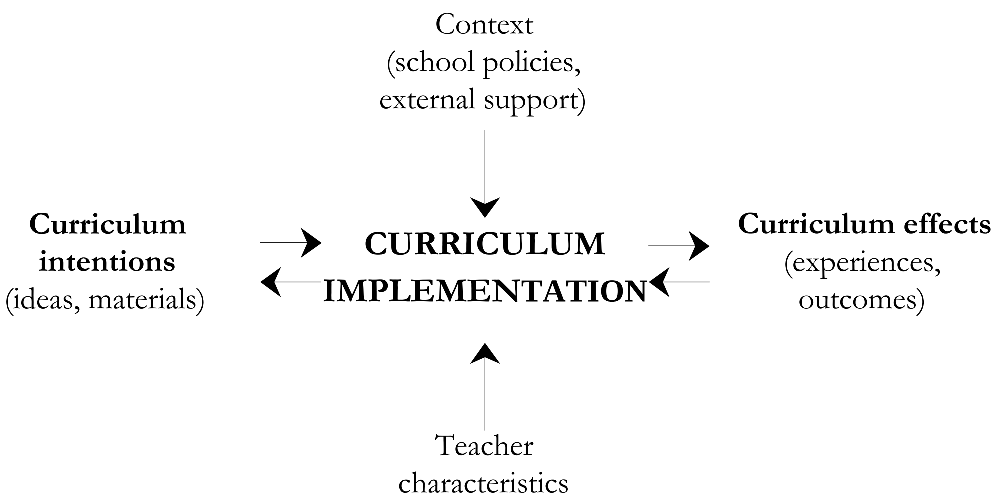


Figure 3.1: A framework for curriculum implementation (cf. van den Akker, 1998b)

This framework has been established on the basis of findings in the developed world, but seems equally valid in sub-Saharan Africa. Section 3.3 explores the various aspects of curriculum reform in the context of sub-Saharan Africa.

3.3 Science curriculum reform in sub-Saharan Africa

The first part of this section focuses on the *intended* science curriculum -- how science curriculum has developed in the sub-Saharan context (3.3.1). The second part (3.3.2 and 3.3.3) concentrates on the *implemented* science curriculum, how it manifests itself in the classroom, and further discusses constraints and factors contributing to successful implementation (3.3.3).

3.3.1 Science curriculum development: policies and practices

Overview of science curriculum development

The science curriculum reforms, which took place in the Western world in the 1960s and 1970s, (cf. Van den Akker, 1998) were to some extent followed in the developing countries (de Feiter, Vonk, van den Akker, 1995; Ware, 1992). The first wave of curriculum reforms in the US and UK, during the 1960s, characterised as 'development projects', primarily focused on science as a subject and the preparation of students for science careers. The teacher was a lecturer and the class worked as a unit. The second wave, on the other hand, was driven by societal issues - environmental issues in particular - and aimed at 'science literacy for all' (Ware, 1992) for students who did not pursue an academic career in science.

Developing countries initially adopted the curriculum from their former colonial powers, at the time of the first wave of curriculum development. Anglophone countries adopted the British General Certificate of Education (GCE) curriculum current in the 1960s in the UK, in a 'mildly modified' (Lewin, 1992, p.10) form. Towards the end of the 1960s, many ministries started to view curriculum development in broader terms than just the rearrangement of a list of topics. In the 1970s large numbers of development project saw the light and these used the first wave British projects, such as Nuffield, as their source of inspiration. Ogunniyi (1986) provides a summary of such projects in the African context.

In developing countries, curriculum reforms in the tradition of the second wave have taken place especially at the level of primary and junior secondary education. With expanded access to schooling, and the shift in emphasis towards Basic Education, 'science literacy for all' has also become a credo in developing countries. At senior secondary level, the curriculum is still very much in the tradition of the first wave of reforms. Emphasis has remained on the preparation of students for a science career at tertiary institutions, and focus on (mastery of) content. The second wave of curriculum reforms has proven to be a lot more difficult to implement than the first one, as there is concern that a 'science for all' approach will not sufficiently prepare those students who choose a science career at the university (Ware, 1992).

Lewin (1992) predicted the following trends for the 1990s in the domain of science curriculum development in developing countries:

- The drive towards scientific literacy for all will continue.
- Teaching scientific skills and cognitive processes related to scientific problem solving and reducing emphasis on the recall of information will remain the curriculum development orthodoxy.
- Technology will form a new focus of interest in curriculum development complementing or even leading to new science curricula with an emphasis on the skills needed to solve real-life problems.
- Broader definitions of science education, including health education, nutrition, science and society issues and environmental issues will become more important.

Now, at the beginning of the next decade, most of those trends are indeed visible, although mostly in primary and junior secondary education. Technology, however, has not had the impact as predicted, primarily due to the lack of resources necessary for technology-based education, the lack of proper policy to govern it and too little investments in teacher development.

An issue in science curriculum reform in Africa is the desire to connect school science more closely to the everyday lives of students and to local traditional practices, sometimes called indigenous science. Following the Science, Technology and Society (STS) drive in the Western world (Keeves & Aikenhead, 1995) came the realisation that the school science curriculum in many developing countries was far removed from the daily lives of students who were subjected to it. It was felt that what was taught in school science was diametrically opposed to the commonplace knowledge that students acquired in the traditional setting (Jegede, 1988). Curricula would not prepare students for their daily lives after school. Indigenous technologies such as tanning, craft, painting, as well as the cultural beliefs students bring to the classroom, which are often opposed to or incompatible with modern science, were given as reasons why STS curricula would be important for developing countries (Jegede, 1988). Science syllabi started to provide opportunities for activities that were found to be relevant for the local context. Local practices were screened for their science content (e.g. in Swaziland, Kruger, 1992) and many of these were incorporated in science syllabi. Attempts to infuse STS activities into existing science curricula, or to introduce completely new STS curricula, were especially aimed at the junior secondary level. The Integrated Science curriculum in Botswana, Lesotho and Swaziland (BoLeSwa) provided science in local contexts. In the BoLeSwa countries, as in many other countries, the drive for indigenous science has left the senior secondary curriculum virtually untouched. This has created the impression that indigenous science is somehow second-hand, 'diluted' science and that the real science is what is offered in the Cambridge Overseas Secondary Certificate (COSC) science curriculum at senior secondary school level.

Curriculum development practices

Walker (1990) defines two basic development strategies, *generic* and *site specific* curriculum development. Generic curriculum development is typically carried out in large-scale projects, at national or state level. Such projects are usually dominated by curriculum specialists, although teachers may have a limited involvement. Site-specific curriculum development refers to activities that take place at school or district level and are undertaken by small groups of teachers (Marsh & Willis, 1995). Almost all curriculum development activities in sub-Saharan Africa take place at national level and are typically generic and top-down in nature. Curriculum development often takes place at semi-autonomous centres (Namibia, Zambia, Tanzania) or curriculum units within the Ministry of Education (Botswana, Zimbabwe). The actual development of the curriculum is normally in the hands of a small group of specialists, supported and dominated by expatriates, with no or limited involvement of teachers. Teachers' involvement in the development process is often limited to suggestions for content in the subject syllabi. In a centralised system, the curriculum tends to be viewed as being '*too important to be left to teachers*' (Mebrathu in Montero-Sieburth, (1992, p. 179*)*. As Peacock (1995, p. 152) states: '*In the case of science curriculum development for primary schools, this has usually been in the hands of expatriate advisers collaborating with local educators in institutes based in capital cities, and has resulted in curricula which departed radically from traditional views of learning*'. Once curriculum documents have been finalised, they are sent to schools for teachers to implement as indicated in the documents, often with little or no support to teachers.

3.3.2 Classroom realities

Educational reform proposals in Africa often focus on changing the classroom practice to an environment that promotes a more learner-centred teaching methodology with active student-involvement in the class. Curriculum changes have effected practice in African classrooms only to a limited extent, similar to what Cuban (see 3.1) observed in the context of the Western world. Few empirical studies of secondary school classrooms in developing countries are available, but the message from them is consistent: very few of the (often unrealistic) goals of the science curricula are being implemented in the classrooms. Adamu (1989) in Nigeria, Prophet (1990a; 1995) and Prophet and Rowell (1993) in Botswana, Macdonald & Rogan (1988) in South Africa, Stuart (1991) in Lesotho, and Rollnick et al. (1998) in Swaziland, all provide details of what happens in science classrooms in sub-Saharan Africa. Results can be summed up as follows:

- students are passive throughout the lesson;
- 'chalk and talk' is the preferred teaching style;
- emphasis on factual knowledge;
- questions require only single words as answers, often provided in chorus;
- students do not ask questions;
- only correct answers are acknowledged;
- very little practical work is carried out.

The circumstances in which teaching takes place in sub-Saharan Africa might be different from those in the Western world, but the African classroom seems as resistant to change as any other classroom elsewhere. The next section discusses some of the constraints to implementation and factors that might positively influence implementation of science curriculum reform in the African context.

3.3.3 Implementation of science curriculum reforms

Constraints to implementation

Support to teachers for the implementation of curriculum changes is often very limited. Curriculum reform programmes are typically accompanied by short in-service training activities, mostly in the form of workshop activities. The enormity of the task in combination with the limited human and physical resources, and the often large geographical areas that need to be covered, make support to teachers at school level problematic. In-service training activities are usually carried out as part of a donor-funded project, which typically has a limited life span of two or three years. The inputs of such projects are often considerable, but unsustainable beyond the (usually short) lifespan of the project. Andrews, Housego and Thomas (1990) observe that in-service teacher training programmes appear to have had little impact on classroom practice, despite the fact that educators in developing countries see ensuring implementation as the most important characteristic of such programmes. The typically strong emphasis on subject content knowledge at the expense of pedagogical skills in in-service training programmes is seen as a limiting factor in its effectiveness. In addition, the lack of incentives (e.g. in the form of qualifications and salary increase) is considered to be a reason for the low motivation of teachers to participate in such training programmes. Lewin (1992, p.157) sums it up as follows: '*… in-service support appears often to be piecemeal and unlikely to exist as part of a long-term development plan. Rather it is concentrated around periods when new curricula are introduced and tends to be one-off in character with limited or non-existent follow-up.*' Ware (1992) sees the absence of well-developed in-service training programmes (as a vehicle for continued professional development) as one of the major obstacles to effective science education reform. In this context, the statement '*The developing world is littered with educational reform proposals that either have not been seriously implemented or that* *were overtaken by events before their effects were transparent*' (Lewin, 1995, p. 3) is illustrative.

Some oft-mentioned obstacles to successful implementation are: insufficient mastery of both subject content and basic teaching skills; language problems for both teachers and students; poorly resourced schools and classrooms; and a misalignment of curriculum goals and examination system (van den Akker et al., 1994; de Feiter et al., 1995). At the teacher and classroom level, studies in junior secondary schools in Botswana (Tabulawa, 1996; Prophet, 1995; Snyder & Fuller, 1990) and in South Africa (MacDonald & Rogan, 1990) show several factors that negatively influence implementation of learner-centred teaching in the classroom:

- the extra workload involved in implementing the new curriculum – the initial cost of the innovation is hindering a proper implementation;
- complexity of the innovation – if the complexity of the task becomes too great, it is unlikely that it will be implemented (for example, curriculum materials are often actively interpreted by science teachers, changing 'discover' to more traditional forms of pedagogy; Prophet & Rowell, 1993);
- negative views of students held by teachers – teachers perceive students as having limited ability, from poor and unsupportive backgrounds, and with poor attitudes towards school;
- teachers' and students' view of their own roles – teachers see themselves as 'delivering the goods' to students; students as receivers of knowledge;
- students' resistance to change – e.g. unwillingness to participate in group work, in favour of covering quickly and efficiently all the material to be tested in the recall-type of examinations (Macdonald & Rogan, 1990, p. 123);
- authority structure in the class – teacher's or dominant student's views, observations and conclusions count most and discourage contributions from other students (for example, teachers keep their authority in the class intact by demonstrating expertise and knowledge of facts; comprehension of biological processes seems less important than knowing the proper English vocabulary for parts of plants; Prophet & Rowell, 1993);
- perceived quality of curriculum materials – materials need to be of good quality; perceived 'cheapness' of materials can hinder implementation.

Factors contributing to implementation

The literature is consistent in its description of what factors contribute to successful implementation of curriculum innovations in developing countries (Dalin, 1994; Fullan, 1991; Lockheed & Verspoor, 1990; Montero-Sieburth, 1992; Rogan & Macdonald, 1985; Verspoor, 1988). Some major messages are the following:

- Educational change should take place in a politically stable environment. Implementation is greatly helped by long-term strategies (usually up to 10 years) and strong support from all formal structures in the educational system.
- In-service training of teachers is at the heart of the implementation process. It should be concrete, locally available, linked to practice, flexible and responsive to teacher needs, should provide opportunities for them to practice new behaviour, build and maintain their commitment, and foster a sense of ownership of the reform.
- To sustain such activities, capacity building in this area should take place by means of building a cadre of in-service providers who are as close to the school and classroom as possible. In-service training programmes in developing countries are often executed via a 'cascade' system, in which qualified and experienced teachers are trained to run in-service courses for their less qualified colleagues (e.g. Macdonald, 1993). Such programmes may often be the only economical way to provide training to the vast numbers of widely dispersed practising teachers. But the training of trainers is usually poorly developed; their experience and exposure to the new programme is often not more than that of those whom they are trying to train (Lewin, 1992). Normally, no incentives exist for trainers who carry out such tasks in addition to their normal workload after school and in weekends. This causes teachers to lose their motivation to contribute to the cascade of training.

Besides favourable environmental conditions for the reform, the nature of the reform itself is also a crucial factor in the implementation. In this respect, Fullan (1991) lists the use of new materials, teaching strategies and beliefs as three aspects to be taken into consideration during implementation. The next section takes a closer look at these three aspects.

3.4 Curriculum implementation as a learning process for teachers

3.4.1 Teachers as students

It is generally acknowledged that teachers play a crucial role in the implementation of curriculum reforms in the classroom. In the context of developing countries, Montero-Sieburth (1992) calls for examining of the curriculum as it is implemented, because '*curriculum change in developing countries will only be as good as the teachers.*' (p. 193).

Teachers need to learn new roles and unlearn old ones. Thus, curriculum reform can be seen as a learning process for teachers. It requires teachers to use new or revised materials and make use of new teaching methods. In addition, in many cases it will involve a change in teachers' beliefs about teaching and learning. Professional development for teachers in support of and during the implementation of curriculum reforms is therefore crucial. Teachers should be provided with opportunities to master new content, to learn new skills, and to practice these in secure settings outside the classroom (Joyce & Showers, 1990). In addition, they should be able to reflect with colleagues and others on what happens in the classroom. Peer coaching can thereby play an important role, also in developing countries (Thijs, 1999).

The next sections discuss the nature of the science education reforms as they take place in the Southern African context. It uses the three dimensions of curriculum implementation forwarded by Fullan (1991) as its guide:

1. the possible change in beliefs (e.g. pedagogical assumptions and theories underlying particular new policies or programmes);
2. the possible use of new teaching approaches (new teaching strategies, activities and behaviours); and
3. the possible use of new or revised materials (e.g. curriculum materials, new technologies).

3.4.2 Teacher beliefs

Serious doubts have been expressed about the feasibility of a learner-centred teaching approach in the context of developing countries (Prophet, 1990b, Guthrie, 1990). Tabulawa (1996) places the observed lack of implementation of a learner-centred teaching approach in a socio-cultural context. The authoritarian nature of the imported educational model of nineteenth century Britain, the missionaries' and colonialists' belief in the supremacy of Western civilisation, the authoritarianism inherent to the Tswana society and the human resource development policy of post-independence Botswana have all contributed to *banking education*: knowledge can be deposited by teachers into containers (students), which can be called upon -- withdrawn -- whenever necessary. He sees the education banking pedagogical paradigm as contradicting the learner-centred teaching proposed in the new curriculum. Attempts to transplant learner-centred teaching methodologies without taking the school and class culture into account will inevitably lead to 'tissue rejection' (Tabulawa, 1996, p. 202).

Tabulawa reports a great measure of congruence between teachers' views of teaching and learning and those of students: 'My foremost responsibility is to impart knowledge and to manage the class, making sure that there is order'. 'My role is to deliver the goods to the students. I have to make sure that I give them notes, and I have to test their understanding by assessing them'. 'Doing work assigned by the teacher' and 'following teacher instructions' are all illustrations of the banking education paradigm (Tabulawa, 1996, p. 200). Tabulawa's study was carried out in Botswana, but there is reason to believe that the concerns he raises are also valid in many other developing countries. Implications are that changing to a learner-centred teaching methodology will require a paradigm shift on the part of both teachers and students.

Guthrie (1990) therefore argues in favour of consolidating and upgrading the existing skills teachers in developing countries are using in a more conventional type of teaching rather than introducing modern Western teaching styles. Others have suggested a similar approach, in which teachers are competent and confident in the basic teaching skills required for effective conventional teaching, but are also open to dealing with more complex goals and student-centred aspects of instruction (de Feiter et al., 1995).

3.4.3 New teaching approaches

In line with developments in the Western world, most of the curriculum innovations in developing countries include a shift from a teacher-centred teaching methodology to a more student-centred one, including more practical activities, inquiry, development of skills and problem solving. The prevailing model, whereby teachers talk and students listen and copy notes from the blackboard, should be replaced by activities in which students are actively involved in the learning process, are engaged in group work, carry out small investigations, and are generally responsible for their own learning, and that of their fellow students. Much has been said about the introduction of these Western-styled teaching methodologies in African educational systems: "*The role of 'internationalism' in educational change is a powerful force that the majority of African nations have difficult to resist. Syllabi contain the correct terminology for the schools of the 90's: pupil-centred learning, building on the pupils' own experiences, well thought out aims, specific behavioural objectives, and so on.*" (Prophet, 1990a). As Guthrie (1990) also points out, there is tension between Western innovation ideas and non-Western cultures, which place great value on respect for elders, wisdom and knowledge, as well as religion. Reflection, criticism, and inquiry emphasised in the school curriculum are often in disagreement with values at the students' home (Prophet, 1990b).

Apart from the question whether such new teaching methods are desirable, there is also the question of how much change a teacher, a school or a school system can absorb. In addition to adequately resourced schools, the new teaching methods require well-qualified teachers with a firm grasp of the content, as well as the pedagogy, and who are able to execute it in the classroom (Lewin, 1992). However, in sub-Saharan Africa, teachers often teach classes for which they are not qualified, e.g. primary school teachers conducting junior secondary classes, or biology teachers teaching physics classes, and must do so in poorly resourced schools.

It might be helpful to look at the 'stages of development' model, originally introduced by Beeby (1966), and later adapted by Verspoor and Wu (1990) and more recently by de Feiter et al. (1995). This model suggests four levels of development (unskilled, mechanical, routine and professional). At the two lower levels, teachers typically have limited to moderate subject mastery, and have some professional contacts with colleagues. Possible change at those levels will be limited and needs to focus on training teachers in subject matter and a few additional basic teaching techniques to make teaching more effective. The model suggests that the introduction of a learner-centred teaching methodology in a system that is at the lower levels of development, will be difficult. Boerma (1993), for instance, in a study in Swaziland on the implementation of an activity-based teaching methodology, observed teachers' lack of mastery of basic teaching skills (questioning, use of homework, general classroom management) as a hindrance to successfully implementing more demanding teaching styles.

3.4.4 Curriculum materials

The development and use of curriculum materials are seen as important strategies for curriculum implementation (Ball & Cohen, 1996; Verspoor & Wu, 1990). In the African context, textbooks are often the only curriculum materials available for both students and teachers. Teachers seldom have access to teacher guides, and they are often not used even when they are available. Teacher support materials, which put more emphasis on what to teach and how to teach it, have found their way into schools only in isolated cases (van den Akker & McKenney, 1996; Boerma, 1993).

Textbooks

Textbooks are often the only resource for teachers in sub-Saharan Africa. They often determine the breadth and depth of the curriculum. Review studies on educational reforms in developing countries (Fuller & Clark, 1994; Fuller & Heyneman, 1989; Lockheed, 1993; Lockheed & Verspoor, 1990; Verspoor & Wu, 1990; Walberg, 1991) show that an investment in the supply of textbooks has one of the highest returns. Availability of textbooks has a consistently positive effect on student learning. Textbooks are supposed to provide teachers with a wider range of instructional activities, and save them time, as no time-consuming notes need to be written on and copied off the board during the lesson. This increases the instruction time, which has a positive impact on student achievement in developing countries (Fuller & Clark, 1994). Despite its demonstrated positive impact, supply of textbooks has been problematic, mostly due to budgetary constraints (Verspoor & Wu, 1990) caused by declining financial resources on the one hand and increased student enrolment on the other (de Feiter et al., 1995). Textbooks in developing countries have varying quality of design and lay-out, are often poorly illustrated, make use of language that is often too difficult for the age group, often do not reflect the current pedagogical approaches, and are of varying physical quality. Moreover, provision of textbooks does not necessarily guarantee their use. In primary classes, textbooks are only used to a limited extent (Lockheed, 1993).

Teacher guides accompanying textbooks outline what to teach and how to teach it, including ideas on assessment and suggestions for classroom management. These guides are seldom available to teachers in developing countries, however (Lockheed, 1993). Teachers appear to rely more on good student textbooks for their teaching, even though textbooks hardly ever provide suggestions on how to teach. They do not see teacher guides, but in-service programmes as the best source for learning about new instructional approaches (Shkedi, 1995).

Teacher support materials

The term 'teacher support materials' is used in this study to refer to materials that can assist teachers with the implementation of curriculum reforms in their classrooms. The development and use of new curriculum materials is seen as an agent for instructional change, provided the practice of the classroom is taken into account. Such a development process would place teachers at the centre of curriculum development and suggests that curriculum materials can make teachers' learning central to efforts to improve education (Ball & Cohen, 1996).

Studies carried out at the Faculty of Educational Science and Technology of the University of Twente has focused on characteristics of such materials precisely in line with the above observations.

On the basis of observed implementation problems faced by teachers, van den Akker (1988) identified four specific areas where existing materials need improvement: lesson preparation, subject content, pedagogy and learning effects. A large degree of structure and detail for each of these areas is required if the curriculum materials are to fill an effective role in the initial implementation of the curriculum. Materials should therefore contain a large amount of concrete information and direction for the role of the teacher in the execution of the lesson. The provision of procedural specifications (Doyle & Ponder, 1977) was used as a central concept in the development of these materials. Materials that incorporate procedural specifications on essential areas of the lesson were developed as exemplary lessons, i.e. a small number of representative lessons were developed to illustrate the specific changes in the curriculum, and to provide effective 'how to do it' support to teachers implementing the curriculum. In a field test, experimental materials developed in this way for primary science were compared with original materials that had been developed at an earlier stage. Results indicated that teachers using the new experimental materials executed their lessons much more in line with the intentions of the developers. Teachers appeared to be more successful in adopting an inquiry approach (as intended by the developers) throughout the lessons, unlike their colleagues in the control group who used the original materials. Teachers in the control group often got lost, were overwhelmed by events in the class, and were busy most of the time handling organisational problems. Moreover, teachers in the experimental group reported that they saw an active role for themselves as facilitators in a discovery process of the students, and were mostly concerned with subject content and pedagogy. Teachers in the control group, on the other hand, often had deliberately taken on a passive role during the lessons and had spent most of their time during the preparation on collecting materials and other logistical problems.

Teachers in the experimental group also reported more frequently that the lessons had been different from their usual lesson materials, and expressed satisfaction with the lesson materials, the lesson process, pupils' performance and the possibility to continue with such a lesson approach.

Similar results have been reported by other studies carried out at the University of Twente. Voogt (1993) designed and evaluated teacher materials (developed using design principles similar to those in the van den Akker study above) to support teachers in the use of courseware in an inquiry-based science curriculum in Dutch senior secondary schools. She reported that the use of printed materials by teachers kept their lesson approaches closer to the intentions of the designers of the curriculum. However, she observed that teachers often used student materials, rather than teacher materials, for the preparation of the lessons. Teachers who did this performed considerably poorer in class than their colleagues who used the teacher materials. Also, they were less actively involved in the support of their students during the lessons and ran more often into technical problems with the courseware (than teachers who used the teacher materials). Effectiveness of the materials was also shown by way of a student test (in a pre-test and post-test arrangement).

Keursten (1994) studied the use of courseware in geography education in junior secondary schools in the Netherlands. The central part of the study focused on the characteristics of (printed) teacher support materials and their influence on the successful implementation of courseware in geography education. As was the case in the other two studies, teachers in this study who used the support materials kept the lesson approach more closely aligned with what the designers had intended. Especially the start of the lesson and the discussion part were better executed in the experimental group than in the control group, who used original teacher materials. Learning results, as measured through a pre-test/post-test construction, were better across the whole range of learning objectives for students in the experimental group.

At a later stage, University of Twente studies by Roes (1997) and van den Berg (1996) describe curriculum materials and their use as organising elements in in-service training scenarios, and subsequently in classrooms.

In Southern Africa, materials development has been a component of several innovation efforts (see van den Akker & McKenney, 1996 for examples from Swaziland and Namibia, where exemplary lesson materials were used both in in-service training scenarios and by teachers in the classroom).

3.5 Implications for the MaC study

Several issues resulting from the previous sections in this chapter seem relevant in the Namibian context and have consequences for the definition of the problem and design of the MaC study:

1. As in most African countries, curriculum development in Namibia is a centralised activity (see section 3.3.1). Implementation is viewed from a fidelity perspective, and developers assume that the curriculum is implemented in line with their intentions. However, curriculum goals are often ambiguously formulated and too ambitious to implement. Textbooks are often unavailable or do not provide the teacher with enough support during the implementation in the classroom. Moreover, support systems and provision of professional development for teachers are often

underdeveloped, and teachers are isolated in their schools. As a result, teachers have to implement the curriculum as they think is best, within the context as described in chapter two and against the background of their beliefs, views, needs and interests. Curriculum implementation can therefore be viewed as curriculum enactment, not by choice but out of necessity.

2. The complexity of the innovation and extra workload involved in implementing it in the classroom have been identified as obstacles to successful implementation (see 3.3.3). Teachers often subvert the new curriculum unknowingly and unwillingly; often they have problems coping with the change. Lack of 'how to' information related to the innovations in classroom practice make teachers incorporate less desirable components into their normal teaching repertoire. This situation was certainly also relevant in the Namibian context. Teaching styles did not seem to change much, despite the teachers' enthusiasm for the new curriculum. Classroom practices were still very much teacher-centred, even while teachers professed that they have changed towards a learner-centred approach. Similar observations have been made in the framework of new teacher training programmes in Namibia, indicating that there was very little clarity about the innovation, perhaps even on the part of the people developing the new curriculum.

3. The Namibian school system, after independence, found itself at various stages of development (see 3.4.3). Some schools, especially some of the former White schools, were at a fairly advanced stage of development. The majority of schools, however, would be at the lowest stage: under-resourced and with a weak organisational infrastructure. Teachers in these schools typically have a very poor mastery of subject content. Rote learning, memorisation and copying notes from the board are the norm in the classroom.

4. Teachers' and students' view of teaching and learning (see 3.4.2) confirm the 'banking education' pedagogical style. Learner-centred teaching methods such as group discussions and role-play are seen as irrelevant for passing exams. To change such a style to a learner-centred teaching methodology would involve changing teachers' and students' attitudes toward teaching and learning (Tabulawa, 1996). The first beginnings of such an attitude change will only take place after teachers and students have experienced and understood the change in the classroom, and have found the change useful and enjoyable: 'Experience precedes understanding' (Gunstone, 1995). Continued support at school level is important for the change to be integrated on a more permanent basis.

Curriculum materials as a catalyst for curriculum implementation

The above issues 1-4 are all relevant in the Namibian situation. Combined, they have made the implementation of curriculum changes seem an insurmountable task for teachers in the classroom. Teachers have to overcome an enormous activation barrier before things would really work for them in the classroom (i.e. when implementing change, things get harder and cost more energy before they get easier). In a chemical reaction, reactants have to get across the 'activation barrier' in order to form a new product or products. This barrier can be overcome by an increased input of energy, or by the use of catalysts to actually lower the barrier to be overcome. The use of catalysts is indispensable to chemistry as they allow reactions to take place faster and easier without the need of expending additional energy. Teachers implementing curriculum changes also have to overcome such an activation barrier. Similarly, a catalyst can be used in the setting of change implementation to lower the activation barrier standing in the way of teachers (see fig. 3.2). The MaC study uses the metaphor of materials as a catalyst for curriculum implementation.

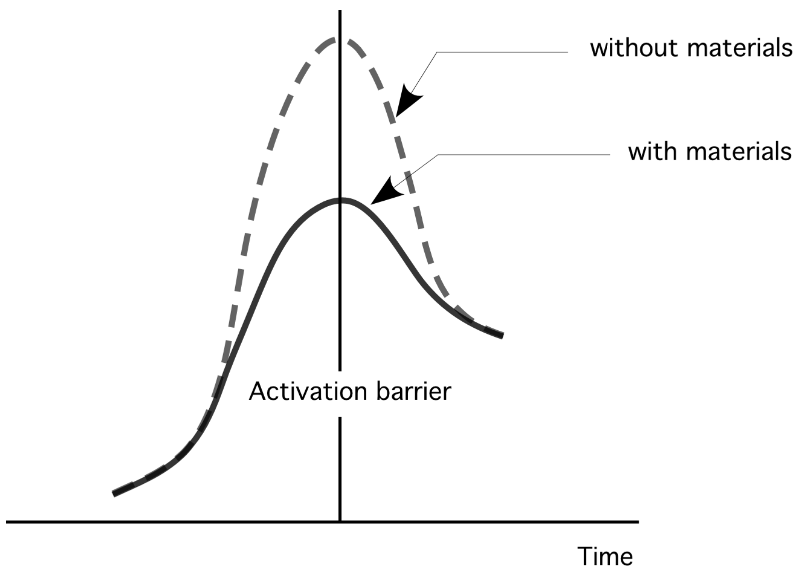


Figure 3.2: Teacher support materials as a catalyst

For a catalyst to act properly, local conditions and circumstances in which it has to do its work need to be taken into account during development. Similarly, development of curriculum materials needs to take account of the local conditions and circumstances in which they will be used. Specifications of a catalyst are established on the basis of a clear understanding of its intended function. Development of a catalyst requires several cycles of testing and refinement before the stage of an effective final product is reached. Similarly, design specifications of curriculum materials would need to be established on the basis of the function envisaged for the materials. Development of the materials would have to happen in an iterative process of design and formative evaluation of the materials in the classroom. Although a catalyst is usually developed for a specific chemical reaction, it might be useful in other reactions as well. Similarly, the materials are developed for a specific topic in the curriculum (as in the case of exemplary materials), but transferability to other topics is envisaged.

Materials as a catalyst for curriculum implementation would have to tackle the various problems identified in under points 2, 3 and 4 above. Point 1 above unequivocally identifies the need for specific support for teachers who are faced with the implementation of a new, centrally developed curriculum. Materials as catalysts in the implementation process will have to be developed with a clear view of the implementation condition, with the teacher and the classroom in mind (cf. Montero-Sieburth, 1992). The development of curriculum materials to support teachers in Namibia with the implementation of a learner-centred teaching style would thus have a number of functions, including:

- to reduce the complexity of the innovation, and to reduce the initial extra workload for teachers;
- to provide teachers with clear and practical ideas for lesson execution and support;
- to support teachers with varying levels of competence in schools with varying degrees of organisation; and
- to provide initial positive experiences with the innovation in order to build understanding and support in changing attitudes and beliefs.

Ball & Cohen (1996) and Montero-Sieburth (1992) call for teachers as central figures in the development process, as well as for research on how the curriculum is implemented in the classroom. The MaC study takes both suggestions into account. The MaC study employs a developmental research approach to answer the central research question. Both development research and the research question are further elaborated in the next chapter.

Chapter 4
Research design

This chapter formulates the research questions and outlines the research design of the MaC study. It introduces development research as the research approach used in the study and its potential in the Namibian context (section 4.2). The MaC study developed along the lines of development research: a front-end analysis, design and evaluation of prototypes, and the evaluation of its effectiveness (section 4.3). Two studies have been undertaken in the framework of the MaC study: the Scientific Processes study and the Materials study (section 4.4). Both studies focused on the design and evaluation of teacher support materials for topics in the new science curriculum. The Scientific Processes study was used as a first study to test the validity and practicality of the preliminary design specifications for support materials (section 4.4.1). The results of this study were used in the subsequent Materials study. The Materials study concentrated on design specifications for support materials for the topic of Materials. A variety of evaluation methods were used, focusing on the practicality and effectiveness of the materials (section 4.4.2). More specific information on research procedures and instruments for data collection will be offered in chapters 5 and 6 dealing with the Scientific Processes and Materials study, respectively.

4.1 Introduction

The MaC study focused on the characteristics of teacher support materials that need to act as a catalyst for initial curriculum implementation. The main question was formulated as:

What are the characteristics of materials that adequately support teachers with the initial implementation of science curriculum innovation in the classroom?

The MaC study developed in three different stages. In the first stage - the *front-end analysis* - it analysed the context of education in Namibia and problems associated with it, and carried out a search for relevant findings from previous research and theory. This analysis resulted in tentative design specifications and guidelines for the development of teacher support materials. Subsequently, in the *development of prototypes* stage, it designed and formatively evaluated prototype teacher support materials that can act as a catalyst for initial curriculum implementation. Finally, in the *evaluation* stage, it evaluated the effectiveness of the materials in the classroom.

From the onset, flexibility was an important aspect of the research design. The Namibian education system was in a state of continuous development and change in the early years after independence. The policy framework for educational change did develop over time, but the local implications could not always be foreseen at the time the research design was established. Moreover, the study was embedded in the framework for in-service teacher training activities of the INSTANT Project. Scheduling of workshops and cluster meetings by the project was often difficult in a situation where communication with the regions and schools was cumbersome, and where teachers and schools had to deal with several different support groups for in-service training. Opportunities to meet with groups of teachers or to observe classes in the context of the study were, as a result, equally difficult. The design of the study as outlined in this chapter emerged over time (compare the notion of emergent design, Smith, 1990). The necessary flexibility could be achieved by conducting several smaller field-tests in different iterations, which could respond to local circumstances at fairly short notice.

4.2 Development research

4.2.1 General concept

Educational development often takes place in complex situations under uncertain circumstances, but with high ambitions. Namibia immediately after independence seemed no exception. Research to support the designers of reform programmes and decision makers can be useful in such situations.

However, traditional research approaches do not always provide sufficient support to design and development efforts in such situations, as answers are often too narrow, too superficial and too late to be useful (van den Akker, 1999). More adequate information and more timely feedback is required for designers to make the right choices in such dynamic circumstances. Development research could provide a useful alternative support in complex situations where needs are diverse, problems ill defined and outcomes of interventions often unknown (van den Akker, 1999).

Walker (1992) sees development research primarily as a means to product improvement: 'to inform the decision making process during the design, production and implementation ... of an educational program with the purpose of improving the program' (o.c., p. 111). Van den Akker and Plomp (1993) define development research by its twofold purpose:

- development of prototypical products (curriculum documents and materials), including empirical evidence of their quality;
- generating methodological directions for the design and evaluation of such products.

During the time the MaC study proceeded, the principles of development research have been further articulated, notably by Richey and Nelson (1996) and Van den Akker (1999). Richey and Nelson describe development research as an inquiry guiding the design, development and evaluation processes. Van den Akker (1999) distinguishes two different types of development research depending on its aims and on the time the research component takes place in relation to its design and development phase: formative research and reconstructive studies.

Formative research includes research activities undertaken throughout the design and development process of a specific intervention (e.g. programmes, materials), from exploratory studies through to formative and summative evaluation activities. These activities are aimed at optimising the quality of the intervention as well as the testing of design principles. On the other hand, *reconstructive studies* represent research activities undertaken mostly after completion of the development process of several interventions. The activities in these studies focus on the articulation and elaboration of design principles.

4.2.2 Development research in the Namibian context

The INSTANT Project in Namibia had been developing curriculum materials right from the onset of the project in 1991. While teachers expressed a great appreciation for the materials, there was very little feedback on the actual use of these materials in the classroom and their contribution to the process of curriculum implementation. Early monitoring exercises carried out by the Ministry of Education and Culture (MEC, 1991; 1993) showed that teaching had not changed to a more learner-centred style, as prescribed by the new curriculum. Instead, the teacher was still the dominant figure in classroom with silent students. The INSTANT Project therefore considered a more careful development process with the teacher in the classroom in mind. Development research seemed an attractive approach for the development of prototypes of teacher support materials in the rapidly changing Namibian context, with their ambitious new educational goals, few qualified teachers, under-resourced schools and unclear implementation conditions. In addition, development research also provided opportunities for testing characteristics of such materials and generating methodological directions.

Van den Akker, Ottevanger and Plomp (1994) explored the potential of development research in developing countries, with emphasis on the Namibian situation. In addition to the two purposes mentioned in 4.2.1, other possible results were considered important:

- better understanding of the local implementation conditions and problems teachers are facing, and
- increased expertise and professional growth of the various participants in the development process.

They argued that in the Namibian situation after independence from South Africa in 1990, many aspects of the educational system were in a state of change. A variety of problems prevented a smooth implementation of curriculum innovations in Namibian classrooms (see also chapter 2). As implementation conditions were often unclear, but varied from region to region - and sometimes from school to school - the use of development research to guide the development of programmes and curriculum materials could take away some of the uncertainties of the development process. The additional outcomes (professional growth and increased expertise of the participants in the development process) was considered to be especially useful in light of the need for building local capacity in developing countries.

According to the typology of van den Akker (1999) the MaC study is a typical example of *formative research*. The aims, emphasis, and projected results of the MaC study are summarised in table 4.1.

Table 4.1: *Focus and projected results of development research in the MaC study*

Development research in the MaC study	
Type	Formative research
Aims	Improvement of teacher support materials (in the form of exemplary lesson materials) and testing characteristics.
Temporal emphasis	Throughout design and development
Results	1. Improved high-quality teacher support materials 2. Lessons learned about: ▪ characteristics of high quality lesson materials ▪ development process of lesson materials ▪ implementation circumstances/problems (useful for curriculum developers, in-service providers, educational planners) 3. Professional growth of the various participants

Formative research is characterised by a mix of development and research. Important aspects of development research activities are its cyclic nature (of design, evaluation and reflection) and the use of formative evaluation as a key activity to establish evidence of product quality and to generate guidelines for product improvement. The following stages can be distinguished in a development research approach (van den Akker, 1999; van den Akker & Plomp, 1993; Nieveen, 1997; Richey & Nelson, 1996):

1. front-end analysis (including context and problem analysis, literature review, analysis of available promising similar examples, review of intentions and perceptions of Namibian curriculum developers;
2. development of prototypes (through a cyclic process of design and formative evaluation activities);
3. evaluation of the effectiveness of the product - in particular in terms of the way it assists teachers with a more practical teaching style with active involvement of students.

These three stages are further elaborated in sections 4.3.1 and 4.3.2 below.

4.3 Developing the MaC study

Parallel to stages in development research, the MaC study consisted of three stages: a front-end analysis, design and formative evaluation of prototypes and reflection on the results, and an evaluation of the effectiveness of materials when implemented. These three stages are further discussed in sections 4.3.1 (front-end analysis), and 4.3.2 (development of prototypes and testing its quality).

4.3.1 Front-end analysis

The *front-end analysis* in the MaC study included a context analysis and problem analysis (described in chapter 2) and a review of the relevant literature on curriculum implementation in the Southern Africa region (chapter 3). Analysis of promising examples of materials development focused in particular on studies similar to the MaC study, was carried out at the University of Twente (see section 3.4.4 for details). Through consultations with Namibian curriculum developers and textbooks authors, the designers of the materials further explored their views on the operational science curriculum (described in chapter 5).

The above activities resulted in preliminary design specifications for teacher support materials deemed valid in the specific Namibian educational context, with its typical problems of a largely unqualified and inexperienced teaching force in science and mathematics, executing an ambitious new science curriculum with unclearly elaborated goals (see chapter 2).

The MaC study included two separate sub-studies: the *Scientific Processes* study and the *Materials* study. The *Scientific Processes* study incorporated the draft design specifications resulting from the front-end analysis in a first prototype of teacher support materials, and tested the validity and practicality of the design.

4.3.2 Development of prototypes and testing their quality

Development of prototypes

The development process in the MaC study was driven by a prototyping approach. A prototype is a 'preliminary version or a model of all or part of a system before full commitment is made to develop it.' (Smith, 1991, p. 42).

The study incorporated important aspects of such a prototyping approach, including the 1) extensive use of prototypes; 2) high degree of iteration through a cyclic development strategy, and 3) participation of (representatives of the) target group (Smith, 1991; see also Keursten, 1994; Nieveen, 1997).

Extensive use of prototypes – The MaC study used an evolutionary prototyping approach: original prototypes of teacher support materials iterated towards a more definite version through continued refinements based on reflections of formative evaluation results. The final version can be considered as the latest version of the original prototype.

High degree of iteration – Development of the prototypes of the teacher support materials took place through a cyclic approach of design, formative evaluation and reflection, comprising several iterations. Interaction with students, teachers, advisory teachers, school principals, textbooks writers and curriculum developers and testing the quality of the materials in settings where they would eventually be used, provided the basis for revisions of prototypes. The iterative process, comprising several smaller studies, provided the flexibility required in the context of Namibia and the INSTANT Project.

Participation of target group –Teachers made very important contributions during the development of the teacher support materials. Teachers' obvious knowledge of their own local conditions, not necessarily always known to the designer in enough detail, contributed to an increase in the practicality of the materials. In return, through a process of reflection on the materials, often as a collaborative exercise at workshops, teachers' involvement in the development process resulted in opportunities for professional growth. Nieveen (1997) indicates positive effects from user involvement in the development process, also relevant to the Namibian situation:

- more accurate information about the tasks which require support;
- more intensive discussions about the requirements of the materials;
- better opportunities to negotiate and justify design ideas;
- increased user commitment and ownership of the final product; and
- professional growth of the participants.

Quality aspects of prototypical curriculum materials

The MaC study set out to establish characteristics of high-quality teacher support materials. It aimed at improving the quality of the materials and testing characteristics for teacher support materials throughout the design and development process. Quality for curriculum materials has three aspects: validity, practicality and effectiveness (Nieveen, 1997). For curriculum materials to assist teachers with the implementation of curriculum reforms, they would need to contribute to the alignment of the intended curriculum with the other curriculum representations (perceived, operational, experiential and attained). *Validity* refers to the use of state-of-the-art knowledge in designing prototypes and internal consistency of the materials, i.e. all components of the intended curriculum (e.g. subject matter, skills, attitudes, pedagogy, assessment) are connected in a coherent and logical way.

If teachers are able to use the materials to execute their lessons in a logical and coherent manner, without too many problems, the materials are said to be *practical*. Doyle & Ponder (1977) defined three dimensions of practicality, *instrumentality*, *congruence* and *cost*. *Instrumentality* relates to clarity and the provision of clear procedures outlining the change. *Congruence* refers to the extent to which a change proposal matches the prevailing conditions. *Cost* involves the investments teachers need to make to implement the change, and the benefits that might result. Practicality of support materials thus implies that the materials should meet the needs, wishes and contextual constraints of the member teachers (Nieveen, 1997).

Effectiveness of teacher support materials as a catalyst for curriculum implementation is a multi-layered characteristic. Firstly, it refers to the extent to which the materials used by teachers lead to lessons, which are in accordance with the intentions of the curriculum developers (congruence between intended and operational curriculum). Effectiveness also refers to congruence between the intended and experiential curriculum (how do students experience the lessons?). Ultimately, however, student achievement can be considered as a reflection of effectiveness, linking the intended and the attained curriculum.

These three quality aspects are addressed in the two empirical studies carried out in the framework of the MaC study, the *Scientific Processes* study and the *Materials* study.

4.4 Empirical studies

The MaC study included two separate sub-studies, the *Scientific Processes* study and the *Materials* study. The *Scientific Processes* study incorporated the draft design specifications formulated during the front-end analysis in a first prototype of teacher support materials. The study tested these draft design specifications. It provided preliminary answers regarding the validity and practicality of the prototype in the Namibian context.

This study was followed by the more elaborated *Materials* study, which used the design specifications tested in the *Scientific Processes* study to develop teacher support materials for the science topic of Materials. The *Materials* study further explored the validity and practicality of the teacher support materials, but gradually the emphasis of the formative evaluation shifted to their effectiveness.

The two studies are further elaborated in 4.4.1 and 4.4.2 below.

4.4.1 Research design of the *Scientific Processes* study

The *Scientific Processes* was the first of two sub-studies in the framework of the MaC study. The study involved the design and formative evaluation of teacher support materials for the topic of Scientific Processes, a new topic in the Grade 8 science curriculum. Designers used the draft design characteristics resulting from the front-end analysis to prepare a first prototype. The study attempted to confirm the validity of these characteristics and the practicality of the teacher support materials when used by teachers in the classroom. Furthermore, the study tried to get preliminary answers on the effectiveness of the prototype. The *Scientific Processes* study was guided by the following research question:

What could be the characteristics of materials that adequately support teachers with the initial implementation of the new science curriculum?

The topic of *Scientific Processes* in the Grade 8 science syllabus deals with a number of basic science process skills such as measuring, observing, classifying, recording and presenting results. The curriculum suggests a learner-centred teaching approach with student involvement and hands-on student activities. It attempts to relate basic science skills to daily life experiences of students. For instance, in an activity about mass and weight, students are asked to measure their own school bags and to compare these with other students' bags. Such activities exemplify the spirit of the new science curriculum: hands-on activities starting with the experiences of the students.

A lesson series on the topic of *Scientific Processes* was developed in a cyclic process of design and formative evaluation, using the following evaluation activities (cf. Nieveen, 1997; Tessmer, 1993):

- Expert appraisal: review of prototypes of a lesson series for the *Scientific Processes* topic by Namibian experts in the field of curriculum development and professional development (from the INSTANT Project and Ministry of Education and Culture), on a continuous basis.
- Field test: of lesson series used by ten teachers in their classrooms in two different educational regions.

The prototype was developed by the researcher with the help of experts at the INSTANT Project and the Ministry of Education in Namibia. Evaluation of the teacher support materials took place in two different cycles. A total of five teachers took part in the first cycle of observations. Four of them were in four different schools in an urban centre in the Keetmanshoop region about 60 km from the capital Windhoek. A fifth teacher was employed at a farm school an additional 15 km from the urban centre. This school mainly catered to learners from surrounding farms. About five or six lessons were observed for every teacher. The researcher and a research assistant saw all lessons in the teacher support materials in operation at least once in the classroom. Teachers kept a logbook of all lessons. All teachers took part in a group interview at the end of the lesson observations. A group of three students from each school took part in interviews at the end of the lesson series.

The second cycle of classroom observations took place in the northeastern part of the country, in the Caprivi strip (Katima Mulilo region), about 1200 km from the capital. Another five teachers (four from the regional capital, and one about 40 km outside) took part in the second cycle of classroom observations, which were carried out by the research assistant who had also been involved in the observations in the Keetmanshoop region. Teachers kept a logbook of all lessons. All teachers were interviewed in separate interviews.

A group of students (about three or four) from each school took part in interviews at the end of the lesson series. The two different regions were chosen because they were rather different in terms of material facilities and organisational infrastructure of the schools, as well teacher qualification and experience (Ottevanger & Benschop, 1995).

A minimal revision was carried out in between the two cycles. It concentrated on a number of inconsistencies between lessons in the description of the lesson executions, insufficient clarity on the role of the teacher in parts of some lessons, as well as providing more specific procedural specifications, and adding emphasis to key areas of text by using a bold typeface.

Besides finding answers to the above question, the *Scientific Processes* study also aimed at finding answers to a number of questions of a more practical nature. Such questions included 'does a development research approach work in the often deeply entrenched practices in developing countries?' or 'are the methods used and the various instruments developed to gather data practical in use'?

This is further elaborated in chapter 5, dealing with the *Scientific Processes* study.

4.4.2 Research design of the *Materials* study

The *Materials* study followed the *Scientific Processes* study. A first prototype of the teacher support materials for the topic of 'Materials' was developed. The designers used the design specifications for teacher support materials tested in the *Scientific Processes* study (see chapter 5). These specifications had shown their suitability in the Namibian situation and were used as a starting point for the development of the prototype. The prototype materials closely followed the Grade 10 textbook (Curry, Linow, Speelman & Tjikuua, 1994) for activities. As the book was developed in close cooperation with the Working Group (of the Ministry of Education and Culture) that had developed the science curriculum, syllabus coverage and internal consistency of the prototype was high.

The development of the teacher support materials for the topic of *Materials* took place as part of the INSTANT Project activities. Experts from within the project contributed to the materials and provided feedback on draft materials (in the areas of format and lay-out, subject matter and pedagogy, on specific activities and their execution in the classroom, and use of language). One of the INSTANT Project members, and editor of the Grade 10 physical science textbook, drafted the text for sections with additional background reading on subject matter notes (teacher notes). This process provided an informal expert appraisal, as it had done in the development of the materials on the topic of 'Scientific processes'. The prototype was used as the starting point in a number of evaluation activities that are outlined in chapter 6.

The topic of *Materials* in the Grade 10 science syllabus provided both opportunities and challenges to the teachers. The topic can be seen as an application of concepts covered earlier in the science syllabus. This approach was different from the usual, more academic science topics, such as *Periodic Table* and *Radioactivity*, which usually lack practical applications of concepts. Another important new aspect of the topic is the connection to daily life. For example, it focuses on materials used for building houses, insulating properties of roofing materials and the strength of bricks. The topic was chosen as the subject for the second sub-study because of its highly innovative character in the Namibian context. Teachers had indicated at in-service training meetings, organised by the INSTANT Project, that they were likely to have problems with the specific subject matter. Moreover, many teachers, especially those in the *former Black* schools, had little experience with conducting hands-on activities and group work.

The *Materials* study was guided by the following research question:

What are the characteristics of materials that adequately support teachers with the initial implementation of science curriculum innovations in the classroom?

The *Materials* study employed a cyclic approach of design and formative evaluation for the development of a lesson series on the topic of *Materials*. Figure 4.1 below shows a graphical representation of the design of the study.

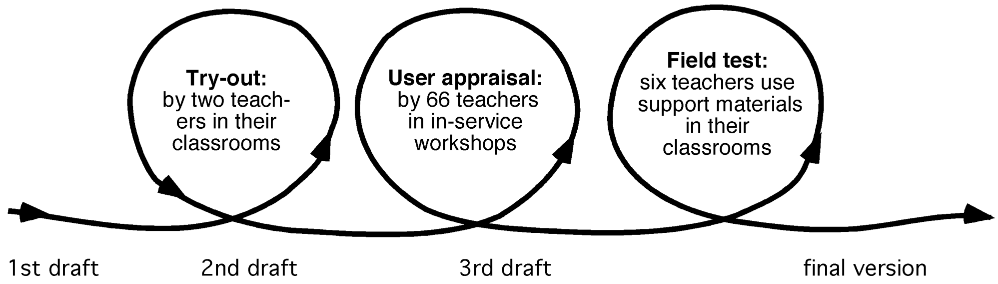


Figure 4.1: Research design of the *Materials* study

The *Materials* study used the following evaluation activities (cf. Nieveen, 1997; Tessmer, 1993):

- Expert appraisal: review of prototype of a lesson series for the *materials* topic by experts, informal and on a continuous basis.
- Try-out: two expert teachers used the first prototype materials in their classrooms, with their students.
- User appraisal: teachers at workshops acquainted themselves with the lesson series on *Materials* by carrying out several of the activities described in the lessons, and provided suggestions for further development. They evaluated the level of activities, the equipment and material requirements in view of their own classroom situations.
- Field test: lesson series used by six teachers in their classrooms in two different educational regions.
- At the end of the lesson series, a student test was developed and administered to classes in the three schools in the Katima Mulilo region, and for logistical reasons in only one school in the Keetmanshoop region.

During the execution of the activities in the different cycles, the focus on quality shifted from validity to practicality and effectiveness (in the later stages of the study). Chapter 6 further elaborates the *Materials* study. Table 4.2 summarises the various aspects of the MaC study.

Table 4.2 *Summary of the MaC study*

Stage in the study	**General description of activities carried out in this stage**	**Specific evaluation activities**	**Focus on quality aspects**
Front-end analysis	▪ Context analysis of education in Namibia (chapter 2); ▪ Literature study of science curriculum implementation, incl. Southern Africa region (chapter 3); ▪ Analysis of available promising examples for similar purposes (chapter 3) ▪ Analysis of local experts' views (chapter 5) ▪ Generating design specifications for materials supporting teachers with the implementation of the new science curriculum		Validity
Design and formative evaluation of prototypes	1. Design and evaluation of teacher support materials for the topic of *Scientific Processes* (chapter 5)	1a. Expert appraisal 1b. Field test	Validity & Practicality
	2. Design and evaluation of teacher support materials for the topic of *Materials* (chapter 6)	2a. Expert appraisal 2b. Try-out 2c. User appraisal	Validity & Practicality
Evaluating effectiveness of materials	Design and evaluation of teacher support materials for the topic of *Materials* (chapter 6)	2d. Field-test 2e. Student test	Effectiveness

Chapter 5
Scientific Processes study

Based on the context analysis of the Namibian education system and following from the theoretical framework, the functions of teacher support materials were identified in chapter 3 (section 3.5). This chapter 5 further explores these functions and reviews the considerations that played a role in determining the design specifications for teacher support materials (section 5.1). The Scientific Processes study was set up to design and evaluate the validity and practicality of the prototype teacher support materials for the topic of the same name. Section 5.2 focuses on the development of the prototype of the materials. Sections 5.3 and 5.4 report on the set-up and results of the evaluation respectively, while section 5.5 draws conclusions from the results. Section 5.6 reflects on the implications for further development of the teacher support materials.

5.1 Towards a first prototype for teacher support materials

This section reviews the considerations that led to the design specifications of the prototype teacher support materials. Important factors that are considered include the functions of the materials (section 5.1.1), and the views of the textbook authors and curriculum developers on the intended and operational curriculum (section 5.1.3). These factors, together with design specifications from related studies, led to tentative design specifications of teacher support materials in the Namibian context (section 5.1.3).

5.1.1 Functions of materials as catalyst

Teachers in Namibia face a number of problems that prevent a smooth implementation of the new science curriculum. In chapter 3 the following

problem areas were identified as stumbling blocks for many teachers:
1. teachers' limited subject matter knowledge and pedagogical knowledge;
2. initial extra lesson preparation time (also caused by a lack of resources);
3. complexity of the innovation (including new subject matter and new teaching methods);
4. teachers' existing beliefs on effective teaching and attitudes towards students.

Based on the context analysis and the theoretical framework, teacher support materials for science teachers in the junior secondary school system in Namibia should provide support in the following areas in order to act as a catalyst for curriculum implementation:
1. subject knowledge;
2. pedagogical guidelines for the execution of the lessons;
3. assistance for preparation of lessons, including suggestions for simple and alternative equipment.

By supporting teachers in these areas, it was hoped that they would create a number of initial successful experiences for themselves. These could assist to change existing teachers' beliefs about teaching and learning and would provide a positive effect on the implementation of the new curriculum. Based on the above functions, design specifications were drawn up. The following section discusses the design specifications in detail.

5.1.2 From functions to design specifications

Initial design specifications for the teacher support materials for the *Scientific Processes* study were based on designs of similar teacher materials used in a series of studies at the University of Twente (UT), discussed in 3.4.4. (cf. van den Akker, 1988; Voogt, 1993; Keursten, 1994). These designs concentrated on four problem areas: 1) lesson preparation, 2) subject matter, 3) teaching sequence (teaching methodology), and 4) learning effects. For each of these problem areas, van den Akker (1988) identified desirable characteristics of materials that support teachers with the preparation and execution of a lesson. The Namibian context differed considerably from the context of the studies discussed in 3.4.4, but functions and desired effects of the teacher materials were similar to those in the MaC study. The first of the studies at the UT (van den Akker, 1988) had developed materials for non-specialist primary school teachers with a limited science background in support of the implementation of an activity-based science curriculum. Later studies at UT (Voogt, 1993; Keursten, 1994, see section 3.4.4) confirmed the design principles for such teacher materials in secondary education. The MaC study incorporated the UT design specifications as state-of-the-art knowledge as a point of departure in its draft design specifications. Table 5.1 provides an overview of the resulting draft design specifications used to develop prototype teacher support materials.

Table 5.1: *Design specifications and their relation to the catalyst functions*

Catalyst function	**Design specifications**
Support for lesson preparation	*General description of lesson* ▪ description of what the lesson will look like ▪ aims of the lesson ▪ references to resource materials and further reading ▪ inclusion of relevant pages from textbooks in use *Lesson preparation* ▪ possible difficulties during the lesson ▪ materials required during the lesson and possible alternatives if not available
Support for subject knowledge	*Subject content* ▪ factual information on (difficult) concepts ▪ possible student questions and answers
Support for teaching methodology	*Teaching strategies* ▪ concrete suggestions for the role of the teacher ▪ suggestions for grouping ▪ suggestions on how to hand out materials ▪ sequencing of activities, including starting up and finishing of the lesson, and drawing conclusions from activities ▪ suggestions for homework
Support for checking learning effects	*Learning effects* ▪ suggestions for student activities, test questions, and homework to check learning effects

In line with the above studies, the design of teacher support materials in the *Scientific Processes* study included *procedural specifications* for crucial elements of the innovation, especially focusing on lesson preparation and lesson execution.

5.1.3 Expert views of curriculum developers/textbook authors

In Namibia, a small and enthusiastic, but heterogeneous group of professionals took responsibility for curriculum development, textbook writing and provision of in-service teacher training for science teachers. The group consisted of members of the Ministry of Education and Culture subject advisory services, as well as members of the INSTANT Project. After the ad-hoc and hurried nature of initial curriculum development immediately after independence in 1990, curriculum development became much more structured (see also section 2.3.8). At the time of the revision of the original science curriculum for junior secondary schools in 1994, textbook development and curriculum development went ahead as simultaneous activities, or at times book development preceded curriculum development. Three of the textbook authors were also part of a Working Group of the Ministry delegated to develop the new science curriculum. In addition, all three authors were involved with the in-service training activities of the INSTANT Project. These three people were considered the best suited to advise the developers of the prototype teacher support materials on the intended curriculum, and how this curriculum would ideally manifest itself in the classroom. In addition, the authors' ideas on the teaching-learning process in the classroom were considered important for the design of the teacher support materials.

To that end, the three textbook authors were interviewed and completed a questionnaire at the start of the *Scientific Processes* study about their views on the intended curriculum. These views are reported by Benschop (1995) and can be summarised as follows:

1. In line with ministry policy, the authors subscribe to the view that learner-centred teaching can lead to a better functioning of students in society, and can develop skills for better functioning in a future job. In the textbook this is addressed by promoting learning with understanding and the development of process and inquiry skills.

2. Learning with understanding is pursued in the textbook by a hierarchical conceptual development, choice of relevant activities for students, and encouraging students to find answers to questions. Illustrations in the textbook are relevant for the local Namibian context. Underlying ideas related to learning are:
   - Involvement and participation are necessary for learning.
   - Students may learn more easily when new concepts are linked with their experience.
   - All concepts are put in an accessible content. The content of the lesson is relevant to students and related to their everyday life.
3. The emphasis in the lessons is on the opportunity for more activity-based student involvement. Teachers decide on the content of the lesson on the basis of students' needs, textbook and syllabus.
4. Students should have an active role during the lessons, should be free to think and make mistakes with the teachers as an advisor in this process. Students should be encouraged to ask their own questions. It is important to let students think and formulate their own opinions. Students should bring their problems and experiences into the classroom, and should not be shy of talking. Interaction between students and teacher should be respectful.
5. Authors see teachers' questioning skills as one of the most important aspects of learner-centred teaching. Students should be encouraged to think more deeply, teachers should not immediately provide answers. Teachers should not continuously stay in front of the class but should mix with (groups of) students.
6. Authors realise that the teachers' role in monitoring learner-centred work is far more demanding and comprehensive than in teacher-centred work. The more the work is learner-centred, the greater teacher's grip on the class must be, if learning is to be effective. During the lessons teachers continuously checks students' progress.

The textbook authors suggest that a 35-40 minute lesson be divided into three components: a) start of the lesson, b) central activity, and c) conclusion of lesson. They stress the importance of the *start* of the lesson. It should take the experience of the students as a starting point, and (new) concepts should be introduced within this framework. Everyday examples of the concepts should be listed and discussed. Teachers should take on the role of facilitator and a source of information, who may also present things to the class.

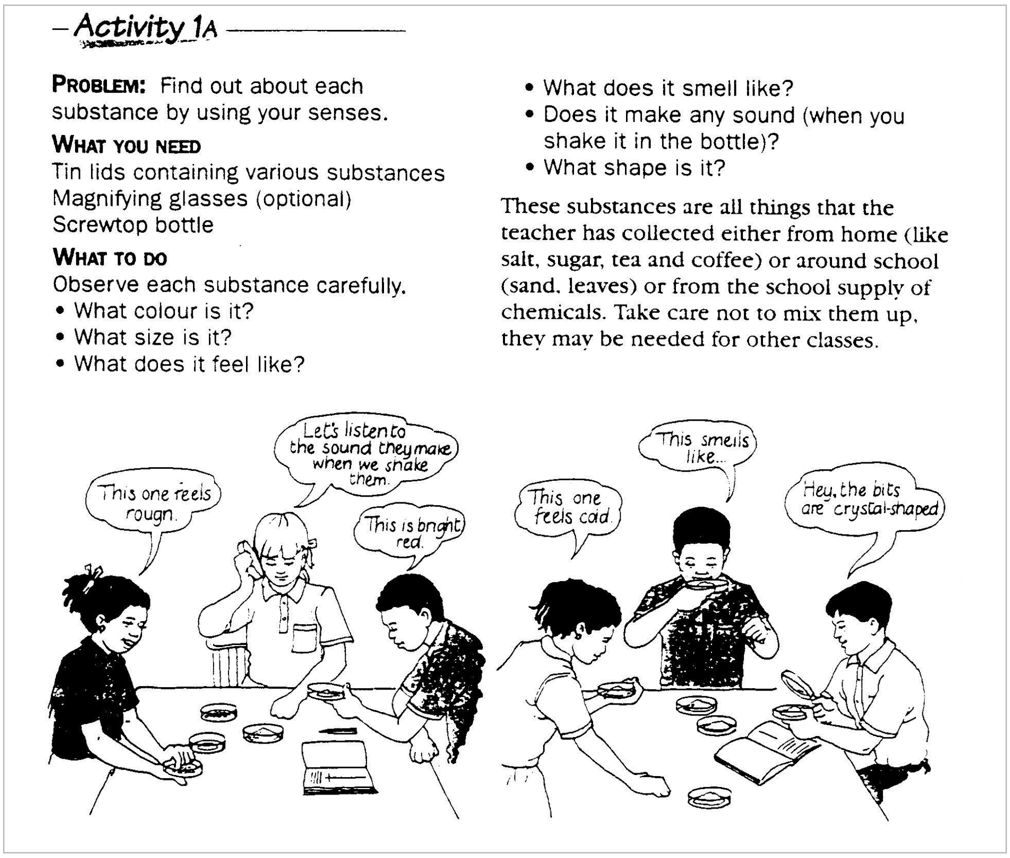
Authors put a heavy emphasis on *activities* during lessons, either in the form of a demonstration or a student activity. They felt that a demonstration can very well be learner-centred if students are involved through questioning, handling equipment, discussion of results and reaching conclusions. Teachers should take on the role as guide and facilitator during such activities. Authors felt that activities are perhaps over-emphasised in the textbook, because they are new to the system. They reckoned that 20 to 50 % of the activities will eventually be carried out as student activities, the rest as demonstration, due to all sorts of difficulties. The authors see the biggest obstacles when carrying out activities in the classroom as:

- not enough time (both per lesson and per school year) and equipment;
- too many students in a classroom;
- shortage of textbooks;
- weak managerial skills of teachers;
- extra time required by teachers to prepare for the lessons;
- teachers do not know how to carry out practical activities;
- overcoming the 'activation barrier'.

Moreover, authors emphasised that teachers and students together should reach a *conclusion* from the activity. In the conclusion part of the lesson, the authors see the role of the teacher as an assessor, as well as a facilitator and a source of information.

5.1.4 Connecting to Physical Science textbook

The Physical Science for Namibia Grade 8 textbook (Curry, Linow & Clegg, 1992) had been available for some time before the introduction of the revised science curriculum. The textbook has a very strong emphasis on activities, and describes activities that students can be asked to carry out in class. Questions guide students in their observations. A series of activities supports the introduction of a number of concepts. Figure 5.1 provides an example of an activity in the student textbook.



– Activity 1A

PROBLEM: Find out about each substance by using your senses.

WHAT YOU NEED

Tin lids containing various substances
Magnifying glasses (optional)
Screwtop bottle

WHAT TO DO

Observe each substance carefully.

- What colour is it?
- What size is it?
- What does it feel like?
- What does it smell like?
- Does it make any sound (when you shake it in the bottle)?
- What shape is it?

These substances are all things that the teacher has collected either from home (like salt, sugar, tea and coffee) or around school (sand, leaves) or from the school supply of chemicals. Take care not to mix them up, they may be needed for other classes.

Figure 5.1: Student activity in Physical Science for Namibia Grade 8 (Curry et al., 1992)

The equipment requirements are kept to a minimum and reference is made to equipment in the science kit schools had received through the Ministry of Education and the INSTANT Project. In many instances, the book makes reference to local practices and situations to which students can relate. Illustrations take advantage of every opportunity to show local applications, e.g. a local windmill, wood stove, or local hero and Olympic silver medallist Frankie Fredericks. Most students in Grade 8 had their own copy of the book; sometimes they needed to share it with a fellow student.

A conscious decision was taken to keep the materials close to the content and activities listed in the book. Designers saw this strategy as a sensible way forward because of the typically strong position of textbooks in developing countries, where textbooks often equate to the curriculum (cf. Lockheed, 1993). Teachers in developing countries often prefer to use a student textbook rather than a teacher manual, although this later phenomena is not restricted to developing countries (cf. Voogt, 1993, Shkedi, 1995).

5.2 Development of prototype teacher support materials

A prototype of the teacher support materials for use by science teachers in Namibia was developed based on: 1) The general functions of the teacher materials as catalyst; 2) the lesson format suggested by curriculum developers and science textbooks authors; 3) the design specifications above.

The designers developed exemplary support materials to *complement* the activities in the student textbook and provide teachers with procedural specifications on how to prepare for such activities, how to guide students to carry them out and how to draw conclusions from the activities.

The *Scientific Processes* study designed and evaluated exemplary support materials for science teachers implementing a topic in the Grade 8 classes called Scientific Processes. This topic was chosen as a vehicle for specifying preliminary characteristics for teacher support materials as it was considered to be representative for the new curriculum philosophy of more active involvement of students in the learning process, and to contain content and activities that are based on students' experiences. This teaching approach was new to most teachers; its hands-on and conceptualised approach differed substantially from the methods employed in the previous, pre-independence, science curriculum.

Appendix 5.1 shows a sample of the materials in support of the activity outlined in the textbook and shown in figure 5.1. The full versions of the materials used in the *Scientific Processes* study are available at www.decidenet.nl/research/tsm_namibia.htm. Version 2.0 was used in the evaluation in classrooms. Evaluation set-up and results are reported in section 5.3 and 5.4 respectively.

5.3 Evaluation of the prototype

Benschop (1995), Ottevanger & Benschop (1995), and Ottevanger, Benschop & van den Akker (1995) reported on the formative evaluation of the prototype of the teacher support materials for the topic *Scientific Processes*. The prototype was evaluated with the help of 10 teachers in two different educational regions of Namibia. An overview of the design of the study is presented in 5.3.1. The curriculum profile, as central instrument in the evaluation, is discussed in 5.3.2.

5.3.1 Set-up of the evaluation

Evaluation of the teacher support materials took place in two different cycles. A total of five teachers, one female and four male, took part in the first cycle of observations (Keetmanshoop region). Teaching experience varied from two years to 16 years. All teachers had a Grade 12 school-leaving certificate, only the three most experienced teachers had an appropriate teaching diploma. Three schools were large schools (in the Namibian context): one school over 600 students, two schools just over 800 students. The other two schools were much smaller with about 200 students.

The second cycle of classroom observations took place in the northeastern part of the country, in the Caprivi strip (Katima Mulilo region), about 1200 km from the capital. Five teachers (four from the regional capital, and one about 40 km out from there) took part in the second cycle of observations, two female teachers, and three males. Four of them had only just started teaching (up to one year of experience), while the fifth had eight years teaching experience. All teachers had a Grade 12 school leaving certificate, one of them held a BSc in Mathematics. Only two teachers had a relevant teaching diploma. Schools were a little smaller than the ones in the Keetmanshoop region, ranging between 207 and 534 students.

On average, four to five lessons per teacher were observed and videotaped. Teachers kept a logbook of all lessons. All teachers were interviewed in a group interview (in the Keetmanshoop region) or in separate interviews (Katima Mulilo region). A group of about three or four students from each school took part in interviews at the end of the lesson series. The two different regions were chosen because they varied considerably from one another in terms of material facilities and organisational infrastructure of the schools, as well teacher qualification and experience (Ottevanger & Benschop, 1995). The choice of such different regions was made in the realisation that variation in evaluation contexts would lead to more robust conclusions about the materials.

Benschop (1995) has described in detail all instruments used in the Scientific Processes study. During the evaluation of the materials in the classroom, the observers made use of a so-called curriculum profile. The next paragraph discusses this instrument.

5.3.2 Applying the curriculum profile instrument

A curriculum profile is a set of statements about intended actions of teachers during lessons (van den Akker & Voogt, 1994). The use of the curriculum profile can be especially effective in formative evaluation exercises. The curriculum profile helps to formulate the relation between the intended and implemented curriculum in very concrete terms. The curriculum profile reflects the central parts of the curriculum innovation and indicates what the designers of the materials would like to see happening (or not happening) in the classroom. The profile is therefore able to point out teacher performances and classroom practices that can be improved and need support. As such, it can provide important data for emphases in the teacher support materials. The formulation of the statements in the profile was based on interviews with curriculum developers and book writers (see section 5.1.3), analysis of curriculum and policy documents, and discussions with relevant staff at the INSTANT Project. The statements in the profile used in evaluation in the *Scientific Processes* study are categorised in three sections:

- positive statements (what designers find important during the execution of a lesson);
- a threshold (a minimum set of actions designers would like to see during the lesson);
- negative statements (those actions designers would rather not see during the lesson).

The completion of a curriculum profile during classroom observations provides a picture of how far the intentions of the developers of the materials have been put in practice. Scoring of the statements on the curriculum profile was carried out as follows: '1' if the statement was a reflection of what was observed, '0' if that was not the case. Sometimes statements were not applicable ('n/a') for a particular situation or lesson.

Positive statements in the profile in this study included 'teacher illustrates lesson topic by doing a (short) practical activity', or 'teacher refers to activities or discussions of previous or next lessons'. Negative statements include 'teacher offers students solutions too quickly (rather than allowing them time to find solutions for themselves)', and 'teacher ignores questions and answers from students'. The threshold sets the minimum condition for the lesson to be successful. For instance, a minimum condition could be that a teacher makes an effort to involve students in practical activities, or that the teacher checks homework at the beginning of the lesson.

Development of the curriculum profile proceeded as an iterative process. On the basis of early classroom observations, the instrument was adapted and extended with extra statements. The curriculum profile was also used as a central organising instrument in the development and revision of the teacher support materials, linking the desired teacher performance in the class with specific instructions in the teacher support materials. Adapting the profile inevitably also meant changing relevant parts of the teacher materials. Statements in the profile needed to be reflected in the teacher support materials. Thus, the curriculum profile had a dual purpose. It was used as a checklist during the development of curriculum materials and as an instrument during classroom observations.

In accordance with the views of the textbook authors and curriculum developers (see 5.1.3), the curriculum profile is divided in three sections: start of the lesson, body of the lesson/activity and conclusion/end of lesson. Additional information on more general over-arching issues of the lesson as a whole(e.g. on time management, blackboard use, preparedness, ability to improvise in a successful manner) was recorded in a fourth section (overall lesson information). Table 5.2 shows the curriculum profile used for the start of the lesson. Appendices 5.2 a-e show all the other sections of the curriculum profile, together with summary scores.

Table 5.2: *Curriculum profile for the 'Start of lesson' section*

Positive elements	*Observer comments*
T. mentions important key concepts	
T. refers to previous and (or) next lesson(s)	
T. asks learners about their ideas on how to carry out the activity	
T. rounds off the start of the lesson wit h a preliminary conclusion	
T. illustrates lesson topic by doing a short practical activity	
T. demonstrates the use of materials or equipment	
T. mentions examples of everyday life related to the topic	
T. manages to let learners ask meaningful questi ons	
If necessary T. assists learners with the correct use of materials, equipment or execution of activity	
T. discusses homework	
T. writes on the board to emphasise important points and information	
Threshold	
T. introduces lesson plenary	
Negative elements	
T. does not check homework	
T. reacts negatively to answer, question, action or behaviour of learners	
T. ignores questions and (or) answers from learners	
T. poses questions, but does not give learners the opportunity to think for thems elves	

There was limited time available between the two cycles for short revision of the prototype teacher support materials. Specifically, several guidelines were clearer and more precisely formulated. For example:

- clearer guidelines supporting the role of the teacher during the lesson, e.g. 'move around to help learners …', 'observe how learners use their materials …', or 'make sure that learners …'.

- more specific guidelines about *numbers* (of items or learners): e.g. ask *six* learners for their answers from the activity' and 'to save time, ask groups to investigate only *two* substances'.
- some suggestions were emphasised by using a bold typeface for parts of the text.

In addition, parts of lesson 1 (too much content for one lesson period) and lesson 6 (last part of the lesson was too complicated for most students) were deleted. In fact, the deleted parts needed to be replaced by extra lessons, but there was no time between the two cycles, and this was delayed until after the evaluation was completed.

The results of the evaluation are discussed in section 5.4 below.

5.4 Results of the evaluation

In order to be able to provide insight in the characteristics of valid and practical teacher support materials, the evaluation focused on:

- how the lessons were executed in class (operational curriculum),
- how teachers felt about the materials and lessons(perceived curriculum), and,
- what the students felt about the lessons (experiential curriculum).

Results of the *Scientific Processes* study are discussed in detail in the original documents, reports and papers: Benschop (1995), Ottevanger & Benschop (1995) and Ottevanger, Benschop & van den Akker (1995). The results are summarised in sections 5.4.1 to 5.4.3.

5.4.1 Operational curriculum

Observers were present in a total of 45 lessons, 22 in the first cycle in the Keetmanshoop region and 23 in the second cycle in the Katima Mulilo region. In the first cycle, both the researcher and a research assistant observed the lessons. This provided the opportunity to discuss afterwards what was observed during the lesson. Initially, there were differences between the two observers, but through the post-lesson discussions observers managed to reach a common focus. These discussions were also useful in sharpening up the curriculum profile. The research assistant carried out the second cycle of classroom observers on her own. The observers kept a running summary of the lessons and videotaped the lessons. They tried to score the items on curriculum profile during the lessons. In some cases scoring was completed after the lesson with the help of the videotapes. Table 5.3 provides individual summary scores for all teachers.

Table 5.3: *Individual summary scores for all 10 teachers for positive and negative profile elements in the different sections of the lesson **

	Teacher										
Profile elements	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Average**
Start of lesson											
▪ positive	76	79	36	82	58	62	61	35	54	55	**60**
▪ negative	13	21	17	21	0	0	10	12	0	0	**8**
Activity/Body of lesson											
▪ positive	88	65	53	64	71	84	88	55	36	38	**64**
▪ negative	0	15	19	0	0	6	5	5	13	0	**9**
Conclusions/End of lesson											
▪ positive	80	56	42	50	58	62	34	17	21	36	**46**
▪ negative	15	6	12	18	11	18	22	27	25	12	**17**
Overall lesson information											
▪ positive	100	90	70	100	100	95	82	43	50	80	**81**
▪ negative	17	3	58	4	0	9	14	72	8	8	**19**

Legend: * Scores are expressed as a percentage of a total score of 100 %. A score of 70 % means that 70% of the items on the curriculum profile were scored

Table 5.3 shows scores for teachers in the Keetmanshoop region (teachers A-E), and teachers F-J in the Katima Mulilo region. The last column shows the average score of all teachers together. Teachers in Katima Mulilo region (teachers F-J) score generally lower for the positive elements on the profile than their colleagues in the Keetmanshoop region, and higher for the negative elements, with the exception of teacher F and to a certain extent teacher G.

Scores tend to be less favourable in the Conclusion/End of lesson section than for the Start and Body of the lesson. Two teachers (C and H) have much less favourable scores in all lesson components. The next paragraphs list observations made in the different sections of the lessons.

Start of the lesson: observations

- Teachers were well prepared for the start of the lessons. The lessons started on time and materials and equipment for the lessons were ready at the beginning of the lessons.
- Students were attentive and appeared to enjoy the lessons. All teachers attempted to draw students actively into the lessons.
- In about half of the observed lessons, on average, teachers managed to pose questions to students to probe their suggestions on how to carry out the lesson's activity, with large differences between teachers.
- In 64 % of the observed lessons, teachers related the content of the lesson to the daily experience of students by mentioning common examples of applications.
- The teacher materials suggested a short introductory practical activity, which was carried out in almost all lessons, with two teachers doing this in the form of a demonstration.
- Students tended not to ask any questions in the first part of the lessons (but they did during the activity and conclusion part of the lesson).

Activity/Body of the lesson: observations

Activities were carried out in the body of many of the lessons. In eight of the classes, these activities were carried out by groups of students. In the other two classes activities took place in the form of 'semi-demonstrations' carried out by a small number of students, while the other students were observing from their seats, after which other small groups of students would do the same. Another format was that teachers divided the class in big groups (of at least ten students) and asked a few of the more skilful students to carry out the activity while the rest of the students in the group observed. In this way, less than a third of the students were actively involved in the activities. Observers also noticed that two teachers had interpreted the suggestion 'divide students in groups of two' as 'divide the class in two groups of students'. Appendix 5.2c provides an overview of summary scores of individual teachers for the body of the lessons. Other observations include:

- With one exception, teachers explained the use of the equipment and materials at the start of the activities.
- Teachers allowed the students a certain amount of freedom in how to carry out the activity.
- Teachers moved around between groups to observe progress, but also to ask questions and to guide students.
- Three teachers formed an exception to the above point: one teacher did not really communicate with the groups of students, only observed them and made notes, and made comments about what he had seen after the activity. At the other extreme, one teacher kept total control over the activity, to the extent that he decided what, how and when the next step in the activity was to happen. A third teacher divided the class in two groups (although the teacher materials suggested having groups of two) during the body of the lesson. After this the lesson proceeded as a plenary lesson, with mostly teacher talk.
- Reporting of the results of the activity did not, as a rule, happen on the blackboard. Instead, it happened verbally, or the teacher checked results while moving around between the different groups. Only one teacher consistently asked students to report their results on the blackboard.

Conclusions/End of lesson: observations

Drawing conclusions from the activity was problematic, mostly due to time constraints at the end of the lesson. Contrary to suggestions in the teacher support materials, conclusions from the activities were often drawn by teachers themselves, and not by students. Similarly, methods used during the activity were discussed in only a few lessons. Appendix 5.2d provides an overview of summary scores of individual teachers for the conclusion part of the lessons.

Other observations include:

- Six teachers asked students, in one or two of their lessons, to draw conclusions from the activity.
- Two teachers discussed the methods used during the activities in all lessons. Five teachers did this in one or two lessons, while three did not discuss methods at all.
- In nearly all lessons, a few minutes were spent on cleaning up and getting the class in order at the end of the lesson.

- Homework was given at the end of most lessons, but this was seldom reported on the blackboard as suggested in the support materials.

Observations of a more general nature

- Both teachers and students had to get used to this kind of lesson. Some of the teachers were initially afraid to hand over the initiative to their students. Teachers tended to talk too much to the class as a whole, both during the introduction of the activity and during the activity itself, distracting students from the activity.
- Teachers executed the lessons in line with the suggestions in the teacher support materials. In a few cases teachers started to use the materials in a later stage (after several lessons) as an exemplary guide, e.g. teachers made their own questions in the format of the questions in the teacher guide, or adapting an activity to suit the local circumstances.
- Large deviations from the lesson suggestions in the teacher support materials, as happened with two teachers (teacher C and H), resulted in all cases in more teacher talk, less student activity (e.g. student activity replaced by a demonstration) and more teacher-centred lessons.
- The same two teachers, although appearing to be well prepared at the start of the lesson, seemed to be missing an overall lesson plan for the lessons, creating confusion among the students.
- English as the medium of instruction created problems for several of the teachers and their students.
- Questioning skills of teachers were often very limited: sentence completion and ignoring incorrect answers were especially prevalent with the more experienced teachers.
- Problems occur when it comes to drawing conclusions. Scores are generally much lower for this part of the lesson than for the other parts. This is especially a problem with teachers in the Katima Mulilo region.

5.4.2 Perceived curriculum

Teachers were interviewed at the end of the lesson series. In the first cycle this happened in a group interview with all teachers together. In the second cycle, teachers were interviewed individually. Important points that surfaced during the interviews included:

On the teacher support materials

- Teachers indicated that they highly valued the teacher support materials. Teachers said that they used most of the information in it, but adapted the suggestions if the local circumstances (e.g. due to lack of resources, too many students in the class) demanded this.
- They appreciated the style of writing, '*as if someone was speaking to you*'.
- Format and layout of the materials (preparation, execution of lessons, etc.) was considered very useful, as was the use of icons to indicate certain lesson components, '*everything is in it, even the timing*'.
- The inclusion of the relevant pages in the materials made it very easy for the Keetmanshoop teachers, but the Katima Mulilo teachers felt that this was unnecessary as they would take the textbook to class anyway.
- Teachers appreciated the 'nice ideas' about how to carry out the activities, as well as the basic information on how to guide group work and how to use (which) materials.
- There was enough information about the intention and set-up of the lesson, and the materials required. The teacher materials had not really shortened the preparation time, but they had made preparation easier. '*It was all prepared for me. I just read through, got the materials and carried them to the classroom*'.
- Asked what the lessons would have looked like without the teacher support materials, two teachers said; '*My lessons would have been very shallow. I think the guide helped me very much in giving a clear picture of what has to be done!*'
- Teachers suggested that the materials should start with an overview of all lessons including a list of materials necessary for all the lessons. This would make preparation easier as more time would be available to plan ahead in finding the required equipment and materials.

On the lessons

- Teachers indicated that the level of the lessons was quite appropriate for the students. Students easily understood the content of the lessons, with the exception of the lesson of graphing results.
- Teachers felt that some lessons were problematic due to the short time available (sometimes only 35 minutes). Limited supply of required equipment (e.g. one bathroom scale for 36 students) also caused activities to run longer than planned. Copying down questions from the board also

took much more time than anticipated in the materials. Teachers found the content of some of the lessons, such as converting measurements from meters to centimetres, and graphing results of measurement, too advanced for their students.
- It was not always easy to find all the required materials (in the Katima Mulilo region), but teachers managed to borrow from nearby schools when necessary.
- Teachers felt that the first lesson should be split in two separate lessons.
- *'These seven lessons were a lot better than my normal lessons'*, said one teacher in the Katima Mulilo region (especially the focus on activities which is not normally the case and the involvement of many more students than normally), when asked whether there was a difference between the lessons. The strong focus on activities and the involvement of many more students than usual were considered especially important contributions to better lessons. Also, the increased attention given to assigning and checking homework was mentioned as another positive aspect of the lessons.

On what teachers had learned from the lessons
- Teachers indicated that they had learned a lot from trying out the lessons in the teacher guide. As one teacher expressed it: *'I think I will get into that way of doing things as in the teacher guide. I already tried it out with the topic of gases and it worked excellently'*.
- *'I learned how to do group work and how to manage groups. I can do it much easier now'*, and *'I learned to give learners enough time to think for themselves'* were some of the answers teachers gave of what they had learned during the execution of the lessons in the teacher support materials.
- Teachers also indicated that the lessons had made them rethink the opinions - often negative ones - they held about their students. The students were capable of much more than their teachers had ever imagined (*'Learners can find much more than you as a teacher can tell them. They come up with questions you did not expect'*).

5.4.3 Experiential curriculum

During classroom observations it had become clear that students tremendously enjoyed the lessons. They eagerly participated in practical activities and group and class discussions. They confirmed this in the interviews and questionnaire at the end of the lesson series:

- Students were enthusiastic about the *Scientific Processes* lessons. They especially liked carrying out the activities for themselves. As one student from the Keetmanshoop region said: *'It gives us a chance to do the things for ourselves and not be dependent on the teacher every time'*. Being involved in group work was another reason why students liked the lessons. *'Because we worked in groups'* and *'If I don't understand it, I can ask if the other people can help me. And they can ask me'* were typical answers.
- Students reported that if they did practical work at all, it was carried out in their normal lessons in the form of a demonstration: *'then the teacher stands in front of the class and he makes everything for us and we see it and we agree'*.
- Students felt that English as the medium of instruction made the lessons sometimes difficult.
- Students indicated that they had no problems understanding the lessons, and that the lessons were equally difficult or easier than their normal lessons.
- Some teachers reported that students from parallel classes, who did not take part in the trial, had come to them with the request to also get such 'nice lessons'. Obviously, students had spoken about the lessons with their fellow students in other classes and had boasted about how nice these were.

5.5 Conclusions from the *Scientific Processes* study

Conclusions drawn from the results are categorised according to the three quality aspects of teacher support materials: validity, practicality and effectiveness. In addition, reflections are made about *initial successful experiences* of teachers. Such experiences are likely to contribute to sustained efforts by teachers to continue with the implementation of the new curriculum.

Validity

Validity, as one of the aspect of quality of teacher support materials, was secured by a number of activities carried out during the development process:

1. Discussions with the various players in the curriculum development process in Namibia provided clear directions for the designers of the exemplary teacher support materials. The science syllabus provided clear instructions of the content of the topic. The student textbook provided further clarifications of the lesson practice for the *Scientific Processes* topic. Support materials were designed to be complementary to the textbook.
2. State-of-the-art knowledge was used to come to draft design specifications for the prototype of the exemplary materials.
3. Design of the exemplary materials was based on 1 and 2 above.
4. Review and continuous feedback of experts from the INSTANT Project and Ministry of Education and Culture.

Practicality

Teachers indicated that they were able to use the teacher support materials without any problems. Teachers felt that the materials were easy to use and written in a style as if someone 'was speaking to them', in the style of what van den Berg (1996) calls a 'written coach'. Teachers appreciated the different components (lesson preparation, execution of lesson, etc) in the materials. In addition, they were happy with the layout and the use of icons to indicate the different lesson components and an indication of the times required for the various components.

All teachers indicated that the level of the lessons was appropriate for their students, although there were some problems with the more difficult areas like creating a graph of experimental results. Teachers felt that materials required for the activity were all obtainable, although especially in the Katima Mulilo region teachers had to go the extra mile to get them, e.g. by borrowing them from other schools.

Observers confirmed that eight of the 10 teachers were using the teacher materials quite comfortably. The other two teachers struggled with them, as was shown during the execution of the lessons. Observers reported that all 10 teachers involved in the evaluation carried the materials to class. They also consulted the materials regularly, especially the questions guiding the conclusion section after the activity, (often posing the questions in the materials verbatim to their students) and to check the times indicated for the various lesson components. The inclusion of the relevant pages of the textbook in the materials met with a mixed reception. Teachers in the

Keetmanshoop region thought that it was a good idea, whereas the Katima Mulilo teachers felt that it was an unnecessary extra, as they take the textbook to class anyway. The extra pages make the teacher support materials rather bulky. It seems justified to leave out such pages.

In conclusion, it appeared that teachers were very positive about the practicality of the materials. They appreciated the materials and saw their use as not only a support in the execution of activity based lessons, but also as a learning exercise. Teachers felt that the materials had clarified for them how to conduct lessons with practical activities and group work. Observers confirmed that teachers were using the materials quite comfortably in class.

Effectiveness

In chapter 4 (section 4.3.2) effectiveness of teacher support materials was defined as a measure of congruence between the intended and the operational curriculum (what is the effect of the use of the materials by teachers on their teaching approach?). Effectiveness also refers to consistency between the intended and experiential (how do students experience the lessons in the teacher support materials?). Ultimately, effectiveness is a reflection of how well the intended and the attained curriculum (what is the effect of teachers using the materials on learning outcomes?) are connected. However, this was not checked in the *Scientific Processes* study.

1. The teacher support materials have contributed to the execution of activity-based lessons, with students working in groups to find answers to problems. Lessons were generally well prepared and well structured with a start, a lesson body with an activity and a finish. In many lessons there was a logical flow of activities.
2. Students' suggestions were often the starting point of the introduction of a concept or an activity. If time allowed, teachers often rounded off the lesson in a reasonable manner. Such well-structured lessons were in normal circumstances (observed as part of professional development activities of the INSTANT Project), i.e. without the use of the teacher support materials, more sporadic, if they happened at all. In the lessons that were observed in the *Scientific Processes* study, there seemed to be more variety of activities (not just chalk and talk) and more depth in the lessons.

3. Teachers see the use of the materials and executing the lessons as a learning experience (e.g. improved questioning skills, better management of group work, more appreciation for students' potential).
4. Teachers closely followed the suggestions support materials, but (at a later stage) started to use the materials more as an exemplary guide, e.g. by using the question format suggested in the materials to frame new questions, or by adapting the apparatus recommended for the activity if they did not have the suggested apparatus available. The exemplary nature of the teacher support materials was also illustrated by teachers using a similar lesson format in other topics not covered by the materials. As one teacher said in an interview after completion of the lesson series: *'I really like them* (the lessons in the teacher materials). *I am now teaching another topic, but I am using the same format for my lessons as in your materials.'*
5. Major deviations from the lesson suggestions in the materials (by two of the 10 teachers) led in all cases to more teacher talk and less student involvement and student activity.
6. Students were appreciative and enthusiastic about the *Scientific Processes* lessons. They especially liked carrying out the activities for themselves and being involved in group work, something which they normally did not do.
7. Students indicated that they easily understood the lessons.

Initial successful experiences by teachers are considered important as these can act as incentives, encouraging teachers to continue using the new teaching strategies promoted in the curriculum and supported by the teacher support materials. In this respect, if the materials are able to create initial successful experiences, this could be considered as an additional aspect of effectiveness. In the *Scientific Processes* study, teachers were very enthusiastic about the lessons and the materials. They felt that they had learned a lot from trying out the lessons. Other answers referred to managing groups of students during activities and the use of equipment and materials. Teachers also reflected on the questioning techniques: *'I learned more how to make them think for the answer and I was really impressed with them'* and *'I learned to give learners enough time to think for themselves'*. Teachers indicated to have been surprised by their students; they found out during the execution of the lessons that students were able to do much more than they thought. It was clear that students enjoyed the lessons. Although teachers did not make any reference to it, it was clear that students' enjoyment was an encouragement for teachers to continue with the lessons. Teachers encouraged students to ask questions during the activities and the conclusion part of the lessons. Teachers were quite happy to be able to answer most of these questions, also with the aid of the teacher support materials. Designers saw such experiences as an incentive for continuing with this teaching style, thus contributing to the effectiveness of teacher support materials.

In summary, materials designed and evaluated in the framework of the *Scientific Processes* study have been shown - in eight of the 10 observed classes - to be a promising support to teachers in their attempts to execute activity-based lessons. The characteristics used as a basis for development (see table 5.1) appear to have led to materials that can be an adequate support to teachers in Namibia implementing the new science curriculum in the classroom.

5.6 Implications for further development of teacher support materials

The results of the evaluation of the prototype materials for *Scientific Processes* suggest that the design specifications used for the development appear to be promising in the Namibian context. It seemed justified, therefore, to adopt the original design specifications outlined in section 5.1.2 as the basis for further development of teacher support materials in Namibia.

Despite the positive results from the Scientific *Processes*, the reports also indicate that there are several areas that need additional attention in the classroom, such as: time management, drawing conclusions from practical activities, formation of groups and conducting group work, and questioning skills. The designers felt that the next versions of teacher support materials should try to address these areas in more detail. However, the designers also felt that support for these areas can only partly be provided by teacher support materials. They suggested that materials should not be developed as an isolated activity, as was the case in the *Scientific Processes* study, but that they should be developed as part of a more comprehensive professional development strategy, in line with current practice at the INSTANT Project.

Designers felt that in the Namibian context an integrated approach of materials development and in-service teacher training programmes would be a fruitful approach.

Firstly, at workshops and other in-service training activities teachers can contribute to the development process by providing ideas and activities from their own practice and provide feedback on drafts of the materials. Secondly, teachers may not always be clear about the intentions of the developers of the materials. A much more careful introduction, explaining the purpose and intention of the materials, would be of benefit to teachers using the materials in the classroom. In addition, at workshops teachers will have the opportunity to practice and discuss, together with colleagues, with lesson activities in secure settings, before taking them to the real world of their own classroom.

These aspirations have been further developed and concretised in the *Materials* study, described in the next chapter.

Chapter 6
Materials study

This chapter reports on the design and evaluation of teacher support materials for the topic of 'Materials'. Experiences from the Scientific Processes study had resulted in recommendations concerning the method of development, the suitability of the design specifications in the Namibian situation, and the implementation conditions in the schools. In the Materials study, the development of teacher support materials was integrated in ongoing in-service training activities of the INSTANT Project. The design specifications resulting from the Scientific Processes study were used as a basis for the development of further prototype materials. Section 6.2 gives an outline of the research design for the Materials study. The development of the teacher support materials happened in three definite phases. A try-out of an initial prototype in relatively ideal circumstances is outlined in section 6.3. The results of the try-out are detailed in section 6.4. The second phase consisted of an appraisal of the materials by teachers in workshops, described in section 6.5. Section 6.6 draws preliminary conclusions and reflects on issues for further development. In the third part, a field test was conducted in two different regions of Namibia to test design specifications of the materials in genuine settings, outlined in sections 6.7 (set-up), and 6.8 (results). Section 6.9 draws conclusions about teacher support materials for the topic of Materials.

6.1 Introduction

The revision of the science curriculum for junior secondary schools in Namibia aimed to redress the content overload brought on by the first curriculum after independence, in favour of more activity-based topics based on day-to-day experiences of students. Such activities aimed especially at students in schools with little or no equipment who had up to then been involved in very few practical activities. Teachers welcomed the changes in the syllabus, but also showed a degree of apprehension. This seemed particularly so for the topic in the new Grade 10 science syllabus (MEC, 1995) called *Materials*. The topic created quite some excitement among teachers as it provided them with ample opportunities to involve students in practical activities, even if science equipment was unavailable. The use of everyday life materials such as clothes, ceramics, building materials such as bricks and concrete, grass for thatch, and cleaning materials makes it possible for teachers to build on the experiences in the use of these materials that students bring to class. However, teachers also expressed concern, as the topic seemed so different from the usual science topics. The practical work, group work, working outside the classroom with students, and the fear that not all of the necessary materials would be available were some of the concerns raised at discussions at meetings attended by teachers from different schools.

The INSTANT Project, bearing the responsibility for support for the implementation of the new science syllabus, saw the topic of *Materials* as essential, but very challenging for teachers. The project therefore decided to make the topic of Materials one of its central components in its Grade 10 in-service training activities, as well as its materials development activities.

6.2 Design and evaluation of teacher support materials for the topic of *Materials*

Together with science education staff at the INSTANT Project, the researcher developed an initial prototype of the teacher support materials for the topic of *Materials*. The designers used the design specifications for teacher support materials tested in the *Scientific Processes* study (see chapter 5, section 5.6), as these specifications had shown their suitability in the Namibian situation. For this reason, these design specifications were used as a starting point for the development of the prototype in the *Materials* study. Furthermore, the prototype closely followed the topic in the Grade 10 textbook (Curry, Linow, Speelman & Tjikuua, 1994), which had become available in the first part of 1995, just prior to the start of the design of the first prototype. As was the case with the Grade 8 science textbook, authors were also members of the Working Group revising the science curriculum for junior secondary schools. Syllabus development and book writing developed as closely related activities. Textbook authors were also involved in the in-service training for science teachers, organised by the INSTANT Project.

Table 6.1: *Overview of lessons in the first prototype of the teacher support materials for the topic 'Materials' (version 1.2)*

	Description of lesson
1	*Revision of basic concepts* - In the first lesson learners will revise elements mixtures and compounds, physical and chemical changes as well as endo - and exothermic reactions. This is done th rough a number of experiments and reflection on the results.
2	*Classifying materials according to their properties* - Learners will bring a variety of objects from home. They will classify them according to materials they are made from.
3 & 4	*Common properties of materials* - Identify common physical properties of each group as classified in lesson 2. Learners will hammer and heat materials and observe the effect these have on them.
5	*Making bricks* - In this lesson learners will made bricks using cement an d mud. In lesson 8 and 9 the strengths of these bricks will be tested.
6	*Plastics* - Learners will investigate different types of plastic. The concept of the polymer will be introduced.
7	*Natural and synthetic fibres* - This lesson will investigate materia ls made from natural and synthetic fibres.
8, 9	*Materials for building houses: bricks* - Bricks being made in lesson 5 will be tested for their strength.
10 & 11	*Materials for building houses: roofs* - In this lesson learners will investigate materials used for making roofs. Setting up an experiment they will test the insulating properties of different roofing materials.
12	*Materials used for making clothes (1)* - Learners will investigate properties of materials used to make clothes. Both natural and synth etic materials will be looked at.
13 & 14	*Materials used for making clothes (2)* - Learners will investigate the insulating properties of different materials. A second investigation concentrates on the ability of materials to absorb water.
15	*Cleaning materials* - Soap and detergents are the topic in this lesson. Learners will carry out investigations in order to come to an understanding on how soaps and detergents work.

INSTANT Project staff contributed to the materials and provided feedback on draft materials (in the areas of format and lay-out, subject matter and pedagogy, on specific activities, their execution in the classroom, and use of language). One of the INSTANT Project members, and editor of the Grade 10 physical science textbook, drafted the text for sections with additional background reading on subject matter notes (teacher notes). This and the feedback provided by other INSTANT staff and Working Group members, comprised an informal expert appraisal, as had been the case in the development of the materials on the topic of *Scientific Processes*.

Table 6.1 provides an overview of the lessons in the first prototype of the teacher support materials (*Materials* version 1.2). Appendix 6.1 shows a sample lesson from this version of the support materials. The full prototype is available at www.decidenet.nl/research/tsm_namibia.htm. Version 1.2 was used in the try-out, outlined in section 6.3.

The *Scientific Processes* study (chapter 5) had suggested that development of materials should be an integral part of a more comprehensive professional development programme. During the *Materials* study, therefore, design and evaluation of teacher support materials were closely linked to the INSTANT Project's programme of workshops and other professional development activities.

Development of the materials took place in a cyclic approach of design and formative evaluation consisting of three definite cycles (see figure 6.1).

- a first prototype of the materials was used in a try-out of the prototype by two teachers and their students.
- a second draft of the materials was the focus of an appraisal by users of the materials (teachers) at a series of in-service training activities.
- a third draft was used in a field test involving six teachers in two clusters of schools.

Each cycle included a design and a formative evaluation component. Results of the evaluation in the first cycle formed input in the design of the second draft, and so on.

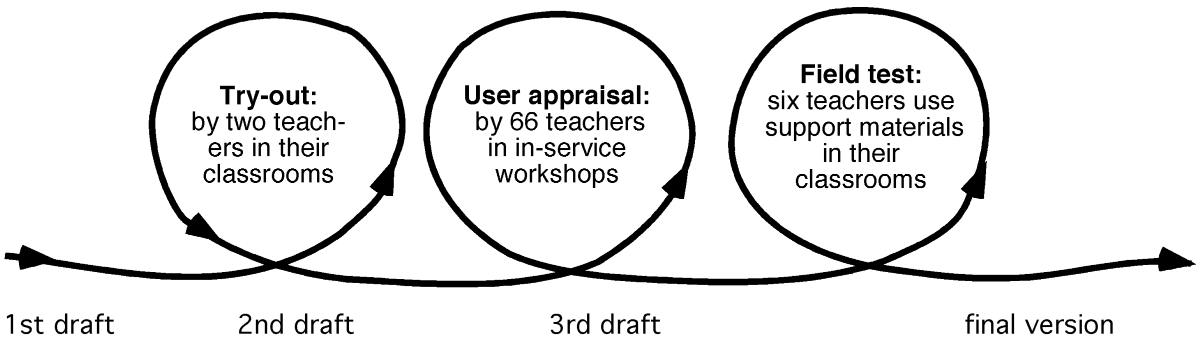


Figure 6.1: Cyclic approach to design and evaluation

Set-up, execution and results of each of the three cycles are reported in sections 6.3 (try-out), 6.4 (user appraisal) and 6.6 (field test).

6.3 Try-out

During the try-out, two teachers used an initial version of the teacher support materials for the topic of *Materials*. This section presents details of the try-out of teacher support materials by two teachers and their students.

A description of the set-up of the try-out is provided in section 6.3.1. Section 6.3.2 gives a short description of the evaluation activities and the instruments used in the try-out.

6.3.1 Set-up of the try-out

A try-out was set up to evaluate an initial prototype of the teacher support materials for the topic of *Materials*. Two teachers and their students in two different schools were involved in the try-out of this first prototype. Both teachers were well-qualified (possessing BSc degrees and teaching diplomas) and had extensive experience (over ten years) as science teachers. The two teachers were heads of their respective science departments and were teaching Grade 12 (final grade) science classes. Both teachers also held senior positions at their schools, one of them as deputy principal. They worked in *formerly White* schools, which were well equipped and had well-organised infrastructures. One of the schools, indicated as *school 1*, was originally an Afrikaans speaking school, but with the new language policy of the Ministry of Education and Culture, had changed to English; at the other school, indicated as *school 2*, English had always been the medium of instruction.

Students in the two schools were traditionally among the best of the country, not only measured by examination results but also by results of students in science quizzes and science fair projects. Furthermore, both teachers were actively involved as regional facilitators in in-service training activities organised by the INSTANT Project. Profiles of the teachers, their students and the context of the schools were chosen such that the try-out would happen in almost ideal circumstances.

Teachers were asked to execute the lessons, making use of the prototype teacher support materials, while keeping in mind the aim of the designers to improve the materials. In this early stage of the *Materials* study, the researcher was interested in how experienced teachers would execute the lessons using the support materials, as well as being interested in additional ideas for activities and lesson execution. Teachers were therefore encouraged to deviate from the lesson suggestions wherever they felt this would be of benefit, but to adhere to essential parts of the teaching approach, including activity-based lessons, student involvement during the lessons and lesson activities based on daily-life experiences of the students. It was hoped that in this way the try-out could not only provide insight in the validity and practicality of the teacher materials, but it would also generate additional ideas for lessons and activities, which could be incorporated in subsequent versions of the materials.

6.3.2 Instruments and procedures used in the try-out

The instruments developed for use in the try-out were based on the instruments used earlier in the *Scientific Processes* study (chapter 5). The curriculum profile, student interview, and student questionnaire are discussed below.

Classroom observations and curriculum profile

The two teachers together executed a total of nine lessons including 3 double period lessons - about 40% of the total lessons in the *Materials* lesson series. Two assistant-researchers observed these executed lessons from their positions in the back of the class. Lessons 2 and 3/4 of teacher 2 were conducted with only one of the observers present. The observers used a curriculum profile based on an earlier version of the instrument used in the *Scientific Processes* study. The development of the new profile took place in consultation with all people involved in the classroom observations and science staff of the INSTANT project. Similar to the curriculum profile used in the *Scientific Processes* study, the profile was divided in four different sections: start of the lesson, body of the lesson, conclusion of the lesson and overall impression of the lesson. Within each of the sections, profile elements were grouped into three categories: basic teaching skills, learner-centred teaching, and classroom management. Different from the previous version of the curriculum profile was the positive formulation of all elements of the profile. The reason behind this was that the use of the profile had, unlike in other studies (van den Akker,1988; Keursten, 1994), a formative character and needed to provide the researcher with indications whether the desired teacher performance in the classroom was actually taking place. The instrument was not used as a means to compare two versions of materials and to come to statements about the effectiveness of the one in relation to the other, as was the case in the studies mentioned above. The section in the profile dealing with negative aspects of teacher performance was abolished altogether, as was the threshold. However, there was room on the form to point to lesson elements that were in conflict with the intentions of the designers. The complete profile is included in appendix 6.2.

The observers completed as much of the curriculum profile as possible during the classroom observations or immediately afterwards on the basis of running summaries of what happened in the class. They did this on separate forms. Scoring of the various elements on the profile proceeded as a *yes* or *no*. Sometimes elements were not applicable (e.g. about checking homework at the beginning of a lesson when no homework had been assigned).

Profiles of two lessons completed by both observers were compared to get an idea of the degree to which the profiles were in agreement with one another. These lessons, classifying materials (lesson 2 in the lesson series) of teacher 1 and making bricks (lesson 5) of teacher 2, were used to compare the observers' scores, and to see how many of the items of the curriculum profile had been scored the same by the two observers. This turned out to be 82% for lesson 2 and 91% for lesson 5. The researcher felt that, in this try-out stage of the study, this provided sufficient overlap to integrate the scores of the two observers. Scores of the lessons were therefore averaged when both observers were present during the lessons.

The two teachers together executed a total of nine lessons including 3 double period lessons (about 40% of the total lessons in the lesson series), five by the teacher in school 1 (the formerly Afrikaans medium school) and four lessons by the teacher in school 2 (the English medium school). The scores are categorised into the three domains basic teaching skills, learner-centred teaching and classroom management. During analysis it was realised that some of the elements on the profile were still formulated in a negative way. A *yes* score therefore really meant a *no*, and vice versa. Scores have been corrected for this. Tables 6.3 to 6.5 show summary scores in the three lesson components (start, body and conclusion of the lesson) as a percentage of the maximum possible scores.

Student interviews

Students were interviewed in two groups, a group of three students from school 1 and another group of four students from school 2. The interview schedule was semi-structured, and based on a previous version used in the *Scientific Processes* study. Some questions were expanded to include more input as to why students had the opinions they did. In addition, it is important to note that the students interviewed in this study were older (Grade 10 students versus Grade 8 students in the *Scientific Processes* study) and therefore capable of expressing themselves more competently, thus the complexity level of the questions could afford to be higher. The student interview plan is available in appendix 6.3.

Student questionnaire

This instrument was also based on an earlier questionnaire used in the *Scientific Processes* study. Twenty-two students from school 1 and 26 students from school 2 completed the questionnaire. The questions were geared towards finding out about students' perceptions about the lessons, about the activities during the lessons, as well as how the lesson had been different from their normal lessons. In an attempt to solicit more thoughtful and focused answers to questions, the question format for a number of the questions was changed (from the previous version) to a sentence completion and fill-in-the-blanks. Questions, which had asked for a more thoughtful answer asking 'why' as a follow-up question, were reorganised into fill-in-the-blanks such as 'because … '. See appendix 6.4 for the student questionnaire.

6.4 Results of try-out

Results of the try-out are presented under the headings *execution of lessons* (6.4.1), *student experiences with the lessons* (6.4.2), and *generation of alternative strategies* (6.4.3).

6.4.1 Execution of lessons (use of curriculum profile)

The two teachers together executed nine lessons, including three double-period lessons. This amounts to about 40% of the total lessons in the series. Table 6.2 shows which lessons the two teachers executed. All these lessons were observed.

Generally, execution of the lessons happened in a very pleasant atmosphere with both teachers and students actively involved. Lessons were lively and both teachers and students seemed to enjoy themselves. The classroom felt like a comfortable place; the teacher and students appeared to enjoy being there.

Table 6.2 *Lessons conducted by the two teachers and observed (T1, T2)*

	L1	**L2**	**L3/4**	**L5**	**L6**	**L7**	**L8/9**	**L10**	**L11**	**L12**	**L13/14**	**L15**
T1		•	•	•			•			•		
T2		•	•	•							•	

Legend: T1: teacher 1; L1: lesson 1;
L 3/4, L 8/9 and L 13/14 are scheduled as double period lessons
See table 6.1 for an overview and description of the lessons
• Lesson executed by teacher and observed

Science related visual aids, such as a periodic table, decorated the walls of the two classrooms. The desks in both classrooms were arranged in rows, focusing the attention on the teacher, in front. There was a strong focus on practical activity, at the expense of theoretical discussion during the lessons. Both teachers seemed confident and competent in the subject areas in all lessons observed.

Start of the lesson

Teachers were organised and ready to start for all lessons. Both teachers introduced the lessons and the key concepts dealt with in the lessons in all but one case, although these introductions were kept short to save time for the practical activity. Teachers had the necessary materials ready for the practical activities. During the introduction, reference was made to previous lessons in seven of the nine lessons. Homework was discussed in two lessons only. Students were attentive in class, something that seemed to be influenced by effective classroom management and an apparent interest in the lessons. In 4 lessons students were asked for their own ideas on the activity in the lesson, or were asked to provide relevant examples from daily life. Especially teacher 2 often used daily examples to illustrate the topic under discussion, e.g. the brick making. She also gave the students supplementary information as part of the introduction on brick making. This was greatly appreciated by the students.

Table 6.3 *Start of lesson – summary curriculum profile scores for all observed lessons for both teachers* *

	T1	T2
Basic teaching skills	87	92
Learner-centred teaching	47	78
Classroom management	78	63

Legend: T1: Teacher school 1
T2: Teacher school 2
* Scores indicated as a percentage of the maximum possible

Teacher 1 kept the introductions deliberately short, not really involving students or asking them for ideas. Nor was there sufficient attention given to the relevance of the lesson. In one lesson of teacher 1, the introduction was skipped so that the full period could be devoted to making bricks. This has resulted in a low score for teacher 1 in the section that deals with these issues (table 6.3), whereas the rest of the scores for the start of the lessons are much higher.

Body of the lesson

Both teachers created worksheets for their students based on the descriptions of the activities in the textbook and teacher support materials. These worksheets guided students during activities (explanation of use of equipment, step by step guidance for execution of activities and drawing conclusions from these). When asked by the observers, most students could easily explain what they were doing and why. This seemed to depend on the quality of the introduction of the lessons.

The testing of materials was not always done according to the recommendations in either the textbook or the teacher guide. In one class, students created their own test for brick strength: a compression test, using a *class mass* (large boy) for the test, which was quite successful. The safety of the students was not always looked after in the most effective manner: the burning of materials was not done in a well-ventilated area; the breaking of glass proceeded without protective eyeglasses or covering(s).

Table 6.4: *Body of lesson – summary curriculum profile scores for all observed lessons for both teachers* *

	T1	**T2**
Basic teaching skills	100	100
Learner-centred teaching	84	99
Classroom management	76	84

Legend: As in table 6.3

Scores are high for all components in the body of the lesson (see table 6.4). This is due to proper (although sometime short) introductions of the activities, explanation of the use of the materials and the teachers being well-prepared for the activity. Students were grouped for all practical activities. Observers noted that teachers moved around in the class and attended to student questions during all lessons. Teachers assisted groups of students whenever they had questions, or wanted to discuss something. It was clear that both teachers had lots of experience with conducting practical work and group work. Teachers gave students the freedom to come up with their own suggestions. Time was used efficiently in all lessons, except in one lesson on fibres, where the activity dragged on for too long, making students restless and bored, and leaving little time for drawing conclusions from the activity.

Conclusion of the lesson

Both teachers encouraged students to draw conclusions from the practical activities carried out during the lessons. Both teachers guided this process through the use of worksheets and asking guiding questions. Reporting on the methods students used to carry out the activity was done in only a few lessons (one lesson 1 for teacher 1, two lessons for teacher 2). Observers indicated that the results from the experiments were not connected to theoretical considerations in either of the two classes. Because of time problems, the conclusion sections were short. In spite of this, lessons in both classes ended with the class in good order, as students assisted teachers with cleaning up of equipment and materials. Homework was given in about half of the lessons, the significance of which was explained in only one of the lessons.

Table 6.5: *Conclusion of lesson – summary curriculum profile scores for all observed lessons for both teachers* *

	T1	**T2**
Basic teaching skills	72	62
Learner-centred teaching	81	75
Classroom management	87	80

Legend: As in table 6.3

The overall impression of the lessons was very positive thanks to a proper organisation and preparation of the lessons by both teachers, and by using time efficiently in all but one lesson. Teachers created a positive classroom atmosphere by asking questions and being open-minded toward student opinions and suggestions, but also by making clear to students what was expected from them. Both teachers were able to improvise where necessary and to adequately use methods different from those in the teacher support materials.

Summary of the main points

Several specific points, both positive and negative, arose (cf. McKenney, 1995):

- Teachers were generally well organised, well prepared and confident in the subject knowledge.
- Lots of practical activities were going on during the lessons.
- Teachers were clearly experienced in practical work and group work.
- Teachers encouraged questions from students and generally showed a good rapport with them.
- Worksheets were used for the introduction of important concepts, to guide the activity (e.g. use of the equipment), as well as for asking questions and drawing conclusions.
- Safety procedures were not always adhered to, despite directions in the teacher support materials.
- More time was needed to complete the lessons. Despite this, some activities dragged on for too long, pointing at poor time management in at least one of the lessons.
- Drawing conclusions from the activities was carried out hurriedly, because of time constraints at the end of the lessons. Connecting results of practical activities to theory was also carried out in a less efficient way.
- Strong practical focus of the lessons occurred at the expense of more theoretical considerations.

6.4.2 Student experiences with the lessons

An inventory of student experiences was made by way of interviews and a questionnaire. Two groups of students (three students from school 1 and four students from school 2) were interviewed at the end of the observation of the lesson series. The questionnaire was administered to 48 students (22 students from school 1, 26 from school 2) at the end of the lesson series. The responses are grouped around the following themes: content of the lessons, practical activities, differences from normal science lessons, teacher-student and student-student interactions.

Content of the lessons

The students interviewed from schools 1 and 2 indicated that the whole class had understood the lessons. They had learned new things, which were useful in real life. In particular, they mentioned that they had not seen the weave of material before, nor did they know that a layer of air could function as an insulator. All four students in school 2 had enjoyed the graphing exercises in the lesson that tested insulating properties of various materials, because it was challenging (this lesson had not been executed in school 1).

There were also concerns. Students indicated that they found the level of the experiments 'too basic'. When asked about what they did not like about the lessons, students from both schools (5 out of 33) commented on the low level of the practical activities: '*classifying materials – the simplicity*', and '*having to test conductivity of materials, having to do it three years in a row*' indicating that some of the activities were review. Another five students (all from school 2) suggested raising the level of the activities. One of the interviewed students (from school 1) suggested that the level was more suited to lower grades. The school 2 students expressed that they would like to have more theory, and wanted a better connection between theory and their practicals, and more connection with the practical applications of theory in the 'real world'. Students in school 1 said that having English as the language of instruction made it very difficult for them.

Practical activities

Given the opportunity in the questionnaire to list two aspects they liked about the *Materials* lessons, the students mentioned the practical activities in general (school 1, n_1=12; school 2, n_2=15), or made reference to a specific practical activity (n_1=16, n_2=22). Asked about their favourite activity in the *Materials* lessons, making bricks and testing them was mentioned most often (n_1=16, n_2=12) as a favourite activity. Reasons given as to why this was their favourite activity included 'using our hands' and 'being outside' (n_1=5, n_2=5), testing the bricks to see whether it would break or not (n_1=4, n_2=6). Another reason forwarded by six students, divided equally over the two schools, was being out of class, in groups, and the possibility to interact with other students. Testing materials by hitting and heating them was another favourite (n_1=3, n_2=14), to observe the changes in the materials when being burned and to see materials crack when they are hit.

Two students of school 1 mentioned exploration of the structure of fibres (using of a microscope) as their favourite activity. One student had wanted more theory on fibres, another indicated to have found the weave of materials very interesting. The third was excited about the breaking (testing) of bricks mainly because he made them himself. In school 2, two students liked the making of bricks the best, because they liked to make new things using their hands. The other two students had enjoyed comparing the insulating properties of fabrics and the graphing of results. The latter because it was a little more difficult than the rest of the activities.

Two students from school 2 indicated in the questionnaire to be unhappy about the rather inaccurate way bricks were tested.

Student-student and student-teacher interactions

Differences from the normal lessons also related to an increase in working together with other students and with the teacher. Ten responses, equally divided over the two schools, related to an increased working together with other students and with the teacher. Specific comments made in this regard in questionnaire responses included:

- *'I liked the groups who worked so nicely together. And for some people it was for the first time they communicated with each other'*
- *'There was more laughing and participation with these lessons. We have learned a lot about each other.'*
- *'It was nice working together as a class together.'*
- *'We as students came closer to the teacher than we usually do by saying what we feel and observe.'*
- *'In our regular classes we just sat there while the teacher gave the lesson. In these lessons we worked with the teacher.'*
- *'It was a lot easier grasping certain concepts with more help and understanding from the teacher. We worked together and everyone's view was heard'*
- *'… and the teacher paid more attention to what we were doing'*
- *'teacher was less strict.'*

One of the students of school 2 indicated that she enjoyed the responsibility given to her for carrying out the activities during the lessons. This was also mentioned as a questionnaire response, possibly from the same student.

Differences from normal science lessons

More than half of the students indicated that the main difference from the normal science lessons was that in the try-out lesson much more practical work was done by the students themselves, with other students, and with the teacher. A total of 26 students made reference to this ($n_1=12$, $n_2=14$). Specific comments included: '*Mostly we were doing things practically. A person can really get lazy just writing things from the blackboard day in day out*'. Students indicated that often the teacher does demonstrations for the students to observe: '*We did the experiments ourselves and this got us into the mood of science. Where as usually our teacher does the experiments herself and we just watch.*'

During the interviews, only one of the three students of school 1 felt that the *Materials* lesson had been different from their usual lessons. There is usually not so much practical work, although there was more of it during the present school year. The other two students of school 1 felt that the lessons had been basically the same as the normal science lessons. The four students from school 2 indicated that there was usually more theory. Practical activities were often carried out in the form of demonstrations, while some practicals were explained rather than carried out, in case they were considered too simple. One of the students indicated that they preferred to do practicals themselves, another student said that too many activities was a waste of time.

The practical activities in the *Materials* lessons were generally judged in a positive sense, both in terms of the content of the practicals, as well as the way these were conducted. However, the activity in which students examined fibres received much commentary. On the one hand, students found graphing the results of the experiment as one of the better (more challenging) tasks. On the other hand, some students indicated that testing the insulating properties of different fabrics was boring as there were long waiting times between temperature readings. They also said that they learned nothing or very little from this activity. As there were not enough microscopes, observing fibres had also been problematic.

In summary, students indicated that the lessons had, in their opinion, been different from their usual lessons because of *more practical activity* and *more opportunity for group work*. They liked the lessons because they had been able to:

- participate, be involved in practical work, use their hands, be outside;
- communicate and work together with their peers in groups.

Specific favourite activities listed by students included:

- make bricks and test their strength;
- test various materials by hammering and burning them;
- determine insulating properties of fibres (the part where students were asked to graph results) and show their academic competence.

In addition, students felt good about being given responsibility and being taken seriously during the lessons. However, students were critical about the lack of a more solid theoretical foundation for the activities. They also indicated that they found many of the lessons too simplistic, repetition of earlier work and requested less qualitative, more accurate ways of testing.

6.4.3 Generation of alternative strategies

During the execution of the lessons, as well as in informal discussions with teachers, several alternatives to suggestions in the teacher support materials were observed and discussed. As teachers allowed students a fair amount of freedom to make their own choices, several good ideas were generated to solve problems. This resulted in some good ideas worth incorporating in future revisions of the teacher support materials.

- Teachers felt that the first two lessons in the teacher support materials were too simplistic and too much repetition of earlier work. They indicated that they would probably skip the lessons, or perhaps combine them.
- A 'science walk' and 'exploring a car' were suggested as activities to collect different materials for classifying, testing and finding out about their uses (replacing the first two lessons in the original prototype).
- Using afternoons to carry out the activities in the lessons. Teachers also mentioned mini-projects as possible alternatives.
- Teachers often used daily life examples to illustrate the topic of the lesson, replacing the idea of a small demonstration as suggested in some of the lessons in the teacher support materials. This alternative, born out of time constraints, was quite effective and attractive.
- In one class, students created their own test for brick strength: a compression test, using a 'class mass' (large boy) for the test.
- Several suggestions were made for alternative materials: the use of milk cartons as moulds for brick making; Coke cans as an alternative for corrugated iron sheets; the use of animal manure in brick making.

6.5 User appraisal

6.5.1 Introduction

After the try-out of the prototype teacher support materials, the researcher together with one of the observers in the try-out revised the materials to attend to some of the observed problems and to accommodate some of the suggestions made by the teachers and students. Developers realised that the try-out had taken place in fairly optimal circumstances, and that the bulk of the teachers and students in the country were operating in a far less ideal situation and that they were less qualified than the two teachers in the try-out (see 6.3.1). It was therefore decided to reserve some of the changes suggested in the try-out until after the wider appraisal by teachers. Especially the suggestion from the try-out that the lessons were too simplistic was not yet taken as a reason to increase the complexity of the lessons. Instead, the developers chose for putting the concepts more in the local context. Thus, version 2.1 of the teacher support materials incorporated the suggestions for revision in the following categories:

1. rethinking the content of the two introductory lessons which were considered too repetitive and simplistic (e.g. suggestions to include a 'science walk' instead);
2. more support for drawing conclusions from practical activities during the lessons;
3. incorporation of several alternatives for activities and lesson execution generated in the try-out.

Appendix 6.5 provides sample materials and an overview of the lessons of this version of the teacher support materials. The full version (version 2.1) is available at www.decidenet.nl/research/tsm_namibia.htm. Section 6.5.2 provides a short description of the evaluation of this second version of the teacher support materials, followed by a summary of the results in 6.5.3.

6.5.2 Description of appraisal of teacher support materials by teachers

In line with the recommendations from *Scientific Processes* study, the materials development process was integrated with professional development activities for teachers who would use the materials in their classrooms. The second draft of the teacher support materials was used at a series of workshops for Grade 10 teachers in the Katima Mulilo and Khorixas regions, in which a total of 66 teachers (54 in Katima Mulilo and 12 in Khorixas) participated. At the workshops, INSTANT staff provided additional information on the subject matter for the *Materials* topic. The workshops also provided a platform for teachers to discuss the learner-centred methodology and the lesson suggestions in the teacher support materials. In preparation for the actual lessons in their classrooms, teachers also tried out, in groups, several of the lessons and activities suggested in the teacher support materials. The researcher used the workshops as an opportunity to collect feedback on the practicality of the teacher support materials. Groups of teachers were asked to fill out an evaluation form (see appendix 6.6) with questions about the general impression of the lesson and activities, possible problems with timing of the lessons, availability of suggested materials and other foreseen problems. They were also asked to provide possible alternative suggestions and necessary adaptations of the lessons in view of local constraints. A total of 87 activity evaluation forms, 68 in the Katima Mulilo workshop and 19 in the Khorixas workshop, were collected for analysis.

6.5.3 Results

At the workshops, teachers tried out lessons on the topics of *science walk, materials testing, roofing materials, bricks, cleaning materials, and fibres*. Instructors distributed the lesson topics from the support materials among the groups of teachers so that several groups would cover all lessons in the lesson series. Teachers could also carry out and evaluate lessons that were of particular interest to them. Teachers acquainted themselves with the lessons in the teacher support materials, carried these lessons out (as students) and provided feedback on them. Teachers' impressions of the lessons were generally very positive. Specific statements in this regard are listed in table 6.6 below. Teachers rated the topic of fibres as less successful than the other topics in the lesson series, mainly for practical reasons such as the lack of microscopes to look at fibre structures and the dead time between temperature readings.

Table 6.6: *Teachers' impression of lessons (total number of responses, n=84)*

Lesson	General impression – some statements by teachers
Science walk (n=18)	Learning while relaxing; makes you think; thought provoking; interesting and easy to conduct; materials easy to find.
Materials testing (n=11)	Full of life and interesting; people might neglect the activity as they are well aware of what will happen.
Roofing materials (n=14)	Very impressive, as it can be done practically; takes a long time to complete.
Bricks (n=14)	Very interesting due to the availability of materials; excellent practice.
Cleaning materials (n=11)	Very clear and encouraging, good but measurements not accurate.
Fibres (n=16)	Not always clear what type of material we were working with; good because students see fibres through microscope; hard to understand, a bit boring

In their responses, teachers in both regions stated that they liked the lessons, as they are full of hands-on activities and stimulate student participation. Furthermore, the activities were easy to conduct and the lessons teach what happens in every day life. See table 6.7 for typical comments made on the lessons.

The responses indicated that carrying out the activities was also a learning experience for the teachers. Typical comments included: *'it was nice because we discovered a lot of materials which we never new'; 'I liked watching it (the fibre) on the microscope and hand lens'; 'because we could see how fibres of different materials are lined by looking through the microscope'*. Teachers also experienced the group activities at the workshop as a good experience: *'group work, because everybody participated'; 'we liked that by the end of the activity a lot of people achieved something'*.

Table 6.7: *What teachers liked about the lessons – (total number of responses, n=68) - Some typical comments*

Lesson	**Comments by teachers**
Science walk (n=15)	'It involves learners' participation, they are actively involved' 'It was fun; it was learning while relaxing. Gave first hand experience on building materials and their uses'
Materials testing (n=10)	'Group work, because everybody participated'.
Roofing materials (n=12)	'It is easy to conduct' 'it is very much impressive, owing to the fact that it can be done practically'
Bricks (n=9)	'It teaches what happens in every day life' 'Very interesting due to availability of materials'
Cleaning materials (n=8)	'The best of it is that it is easy to conduct' 'The activity was clear and to the point'
Fibres (n=14)	'We liked the hands-on' 'Good because learners see fibres through the microscope'

Although teachers seemed positive about the lessons in the support materials, there were also concerns. These are grouped below around the areas of: time, practical activities and group work, safety, and materials availability.

Time - About 30-50% of the returned feedback forms, depending on the lesson topic, indicated that *time* allocation for many of the lessons was too tight. It would be difficult to finish a lesson in a single 30-40 minute period. A total of 36 responses, fairly evenly distributed across the various lesson topics, suggested that the lessons should be carried out during double periods. In another 21 responses teachers suggested that the activities should ideally be carried out as afternoon activities, during study time, or in project form, whereby the presentation of results could take place during regular lessons.

Practical activities and group work – When asked how they would adapt the lesson in the classroom, teachers indicated that they would conduct the lessons as practical activities (48 out of 85 responses). Seven responses specifically indicated that they would try to carry out the lessons in the same way as they themselves had carried them out at the workshop. Three responses referred to demonstration rather than student practicals because of shortage of the necessary materials and equipment. Another 11 responses suggested that they would divide students into *groups* and assign them tasks. Some teachers suggested adaptations in order to keep better control of students, and to make efficient use of time, by using homework to carry out part of the activity. Exploring a car rather than the school grounds would give better control of the students. To save time, students could be asked to identify materials at home, which were collected during the science walk.

Working outside (e.g. during the science walk and during making bricks) brought a key concern into the discussion: maintaining *control* (32 out of 87 responses) and attention of students when outside the classroom. Although teachers find that several of the activities need lots of space and are messy and are preferably carried out outside, teachers are concerned with the possibility of losing student participation when working outdoors. Students may wander off when outside, make noise, which the principal may not like and may not understand. Other teachers (n=9 out of 87) are worried that outdoor conditions such as wind and sunlight might influence the experiments.

A small number of responses (n=6 divided over two questions) were recorded with regards to the complexity of the molecular structures of polymers and oils. As one teacher stated: '*the problem with this activity … is that there in so much information (complicated) and not enough practical work. I just feel I like talking so much because it is hard for them* [the students] *to understand this bonding & structure information.*'

Safety - On 15 of the returned evaluation forms reference was made to *safety*. Teachers were concerned about the lack of safety measures during some of the activities. The Science Walk activity was mentioned nine time in this respect. It was suggested that gloves be used when picking up object from around the school, Also, the testing of materials by hammering caused several comments. Safety glasses when hammering pieces of glass and ceramics were suggested on three occasions.

Materials availability - Teachers (40 out of 86 responses) said that most materials needed for the activities would be easy to obtain, especially if preparation would be done well in advance. However, there were some specific items that would be difficult to get at school. For instance, microscopes, an essential piece of equipment in the fibres lesson, were mentioned four times (out of 16) as not available and difficult to get. Ceramics (7 out of 18) was mentioned as not very easy to get. Cement for making bricks was another problem item (mentioned by 10 out of 15). Three groups suggested that this could be bought from school funds. Corrugated iron for the activity, which measures the insulating properties of roofing materials, was mentioned six times (out of 15) as difficult to obtain. Grass in the desert of Khorixas region will be difficult to find (mentioned three times).

6.6 Preliminary conclusions on the teacher support materials

The try-out and user appraisal mainly focused on the *validity* and *practicality* aspect of the teacher support materials. During the try-out, both teachers and their students felt the introductory lessons in the lesson series were too much a repetition of concepts covered in earlier grades and should therefore be left out. As alternatives they suggested to start with a 'science walk' around the school grounds. In a kind of treasure hunt students collect different types of materials, which can later be tested for their properties. A similar suggestion involved an exploration of the materials present in a vehicle. These suggestions appeared to work very well when carried out at the workshops during the appraisal. These activities also provided a simple theoretical base for the topic as a whole, which had been missing in the first prototype. Equipment and materials did not seem to be a major problem during the try-out. Teachers at the workshops did not see major problems in this respect either.

The use of worksheets in class was not emphasised in the teacher support materials. Teachers traditionally use these as a tool to guide student activities, and this also appeared to be very efficient in guiding activities during the lessons in the try-out. For this reason, the use of worksheets was incorporated for a small number of activities in the second version (version 2.1) of the teacher support materials.

Classroom observations during the try-out shed some preliminary light on the potential *effectiveness* of the teacher support materials. The use of the materials appeared to contribute to lessons with plenty of student involvement and practical activities. Students confirmed that they had carried out more practical activities than usual. An important observation by students was that they appreciated the fact they had been given more responsibility during the lessons and that they had been taken more seriously than normally. One major shortcoming observed during the lessons in the try-out was the absence of a theoretical framework for the practical activities. This was emphasised by the fact that drawing conclusions from the activities was not always carried out in an efficient manner, and was sometimes left out completely (possibly due to lack of direction for it in the teacher support materials, sometimes due to lack of time). Again, students commented on this in interviews with them.

The use of the support materials during the workshops made it very easy for teachers to come to a clear understanding of the intentions of the curriculum. The detailed lesson suggestions had made it possible for teachers to discuss the lessons with colleagues (regarding equipment/materials requirements, level of the subject matter, timing, constraints and alternatives). The materials also provided a solid base for trying out the lessons by teachers at the workshops. The introduction of the *Materials* topic at the workshops generated much enthusiasm among teachers for the lessons, the suggested activities and the advocated teaching approach. The opportunity for teachers to contribute to the teacher support materials by providing additional suggestions and details of local practices enhanced teachers' enthusiasm for the topic. In microteaching sessions, groups of teachers practised a number of the lessons in the teacher support materials. These sessions were of somewhat limited use, as peers found it very difficult to make critical comments about a colleague who had taken the role as a teacher. Teachers said that it was unheard of to criticise a colleague, *'next time they might criticise you'*. In a discussion afterwards teachers maintained that this was not part of their culture. Although this is perhaps true, it was also observed that teachers seemed to lack the ability to reflect on their own lesson practice beyond problems related to time and materials required for the activities in the lessons.

In summary, the teacher support materials together with the workshop activities provided teachers with a view of how the *Materials* lessons could take shape in their classrooms. They had used the materials to practise the execution of the lessons, in groups of teachers. In addition, teachers made important contributions to the development of the materials by outlining and demonstrating local practices. In the Katima Mulilo region teachers at the workshop provided important input on the use of local materials, especially how grasses and which types of grass were used as roofing material, and how houses are built locally. During the workshop, a number of teachers collected grass samples over tea time and gave an impromptu and impressive lecture on the different types of grass and their uses in their community.

6.7 Field test

6.7.1 Introduction

The field test was the third part of the design and evaluation of teacher support materials for a topic of the new junior secondary science curriculum, called *Materials*.

The field test was set-up to get a view of the quality of the teacher support materials for the *Materials* topic, in particular the practicality and the effectiveness of the support materials. The field test focused, therefore, on how the teacher support materials were used in the classroom and how they contributed to the preparation and execution of the lessons. In addition, the field test sought to find out how teachers and students perceived these lessons, and how students would perform in a test at the end of the observation cycle.

The results obtained in the previous evaluation activities (see sections 6.4.and 6.5) were used for the further development of a new version of the teacher support materials. Section 6.7.2 highlights the main changes in the new version. Six teachers used the new draft in a field test. Characteristics of the teachers and their schools are presented in section 6.7.3. Instruments used in the field test are discussed in section 6.7.3. The results of the field test are presented in 6.8.

6.7.2 Revision of the teacher support materials

On the basis of the results of try-out and user appraisal in the development of teacher support materials for the topic of *Materials,* the suggestions made for the next version of the materials included (see also section 6.5):

1. To remedy the observed lack of theoretical basis, the lessons needed better focusing around the central aspects of the topic of *Materials*. These are '*the use* of materials', '*properties* of materials', and '*structure* of materials', and the relation between these aspects. The resulting lesson activities were also much better linked to the *uses-properties-structure* trinity of materials thus providing a better embedding in the theory.
2. The introductory lessons needed to be adapted to accommodate some of the suggestions made by the teachers in the try-out.
3. More time was needed for carrying out the activities. Lessons need to be written up as single lessons as not all teachers have double periods at their disposal.
4. More attention and support for drawing conclusions from activities was needed. Providing a simple theoretical foundation (see point 2 above) will make it simpler to link results from practical activities to theory.
5. In revising the teacher support materials, the designers realised that the teachers (and students) in the try-out were among the best in the country and quite a bit ahead of many of their colleagues in the north of the country. They therefore decided to take small steps in the revision of the teacher support materials, and try them out and wait for the results from the broader field test before making definite changes in lesson complexity.
6. To link the introductory workshops to the actual lessons in the classroom, pictures of workshop activities were included in the teacher support materials.

Incorporation of these suggestions led to the next version of the teacher support materials. Appendix 6.7 shows an overview of the lessons in this version (version 3.1), and one of the lessons as a sample.

6.7.3 Schools and teachers in the field test

A total of six teachers in six different schools took part in this field test. Three schools were located in the Katima Mulilo region, and three in the Keetmanshoop region in the country. Details of the schools are shown in table 6.8. Three schools (two in Katima Mulilo, one in Keetmanshoop region) cater to students up to junior secondary level (Grade 10). The other three schools also include senior secondary grades (Grades 11 en 12). The number of students per school varies from 250 for one of the smaller rural junior secondary schools to 840 for the school offering all classes (Grades 8 to 12) at secondary level.

Table 6.8: *Schools in this field test (S1-S6)*

	Katima Mulilo			**Keetmanshoop**		
	S1	*S2*	*S3*	*S4*	*S5*	*S6*
Grades offered	9-12	1-10	8-10	8-12	8-10	8-12
Number of students	533	572	296	840	250	370
Number of teachers	20	22	10	36	11	16
Physical science teachers	2	2	2	3	1	2
Year of establishment	1979	1975	1990	1971	1964	1980
Boarding facilities(yes/no)	no	no	no	yes	yes	yes

Typically, schools in the Keetmanshoop region have boarding facilities, whereas such facilities are scarce in the Katima Mulilo region. Science departments are small, on average two science teachers per school. Most science departments in the schools lack equipment for practical work and principals indicate that it is often difficult to get additional equipment from the ministry. Schools usually have a small budget for buying small items from the market or stores. Professional development of staff in the schools is left to outside agencies, e.g. advisory teachers from the Ministry or staff from projects such as the INSTANT Project, although principals of the schools indicate that they see a stimulating role for themselves through classroom visits.

Table 6.9: *Teachers in this field test (T1-T6)*

	T1	T2	T3	T4	T5	T6
Region	KM	KM	KM	KMP	KMP	KMP
Gender	male	female	male	female	male	male
Teaching experience (years)	8	12	16	5	1/2	8
Highest academic qualification (in science/maths)	BSc (Physics)	Grade 10	Grade 10	Grade 12	Grade 12	BSc (Maths)
Teaching qualification	no	ECP*	ECP*	HED*	no	STD

Legend: KM: Katima Mulilo; KMP: Keetmanshoop
ECP: Education Certificate Primary
HED: Higher Education Diploma (Secondary)
STD: Secondary Teaching Diploma
*: Non-science/maths

The six teachers in this field test have a quite varied professional background (see table 6.9). One teacher has just left secondary school, is inexperienced and unqualified. At the other end of the spectrum, one teacher has a BSc degree, a teaching qualification and eight years experience as a science and maths teacher. Like many teachers in this region, two of the Katima Mulilo teachers in this field test have a primary teaching certificate. Such a certificate offers some general science, but not enough for the level of the Grade 10 physical science. All teachers had been to preparatory workshops on 'Materials' about a month before they started their involvement in this field test.

6.7.4 Instruments and procedures used in the field test

This section discusses the instruments for collection of data used in this part of the study. The following instruments were used and are discussed below:

- Curriculum profile (during classroom observations)
- Teacher logbook
- Teacher interviews
- Student questionnaire and interviews
- Student test

Curriculum profile/classroom observations

Similar to the classroom observations in previous evaluation activities, a curriculum profile was used to guide the classroom observations. A curriculum profile is a set of statements about the activities and preferred behaviour of teachers during the observed lessons (van den Akker & Voogt, 1994). The use of the curriculum profile helps to establish the relation of the intended curriculum to the implemented curriculum at a very concrete level. The profile in this field test was adapted on the basis of earlier experiences with it in the try-out. The statements on the profile were grouped around three themes: basic teaching skills, leaner-centred orientation, subject matter as well as a section focusing on general lesson information. See appendix 6.8 for the curriculum profile used in this part of the study.

Two observers -the researcher and a research-assistant- took part in the classroom observations, one observer in each region. Both had been involved in the design of the teacher support materials, and as facilitators in the in-service training workshops where teachers appraised the support materials (see section 6.5). They kept a running summary of the lesson and videotaped the lesson with a stationary camera situated in the back of the classroom. The designers had communicated to the teachers that they wanted to evaluate how the teacher support materials assisted the teachers with the lessons of the *Materials* topic. Teachers were left free on how they would execute the lessons, as long as they would use the support materials in one way or another. All lessons in the lesson series were observed at least once and some lessons more often (see table 6.10). The observers filled out the profile as much as possible during the observed lesson. Lesson reports together with the videotapes were used after the lesson to complete the curriculum profile wherever observers had not been able to complete it during the lesson.

A total of 32 lessons were observed, distributed fairly evenly over the six teachers involved in the evaluation, at about five lessons (a third of the total number of lessons in the lesson series) per teacher. The observations took place with two groups of three teachers, one group in the Katima Mulilo region and another in the Keetmanshoop region (see tables 6.6 and 6.7), on either side of the country, about 1700 km apart from each other. The researcher and a research-assistant conducted the observations simultaneously, one in each region. As Teacher 2 had already started to conduct the lessons before arrival of the observer, the first lesson observed was lesson 8. Teacher 1 wanted to pick some of the lessons he found interesting and challenging, and started with lesson 10. The other teachers (T3-T6) started with the first lesson of the series. Table 6.10 provides an overview of the observed lessons. In some cases the lessons in the teacher support materials proved to be too long for the available lesson time and were split over two sessions. The second session in such cases is indicated by the suffix 'a', e.g. lesson 10 by teacher T1 was carried out in two sessions, therefore 10 and lessons 10a.

Table 6.10 *Lessons conducted and observed for the six teachers (T1-T6)*

	1	**2**	**3**	**3a**	**4**	**5**	**L6;7**	**8**	**8a**	**10**	**10a**	**11**	**12**	**13**	**14**	**14a**
T1										•	•	•			•	•
T2	o	o	o		o	o	o	•	•	•		•	•	•		
T3	•	•	•		•	•										
T4	•	•	•		•	•	•									
T5	•	•	•	•	•	•										
T6	•	•	•		•											

Legend: • Lesson executed by teacher and observed
o Lesson executed by teacher, not observed

As in previous classroom observations, the curriculum profile guided the observers. Every lesson was divided (for observation purposes) into three parts (start of the lesson, body of the lesson, and conclusion). For every part, the curriculum profile specified three main components: basic teaching skills, learner-centred orientation, and subject matter (see appendix 6.8 for the curriculum profile used). In addition, a section in the curriculum profile provides opportunity for more general comments on the observed lesson: overall impression. Results shown in tables 6.12 to 6.15 are summary scores for all observed lessons per teacher.

Teacher logbook

Teachers kept a logbook of all the lessons that were observed. The logbooks provided the developers with feedback on teachers' perception of the lessons, and gave factual information on preparation time, problems with required materials, timing of the lessons and so on. Teachers also indicated how useful they found the activities suggested in the teacher support materials, and whether they felt that their students had easily understood the lessons. As was the case with a number of other instruments, the logbook was based on the similar instruments in the Evaluatiewijzer [Directions for Evaluation] (Keursten & Nies, 1993). Appendix 6.9 provides a sample of the logbook used during the field test.

Teacher interview

The observers of the lessons interviewed teachers at the end of the lesson observations. The interviews were audio-taped and transcribed. The interviews were semi-structured and concentrated on teachers' expectations and general impressions of the lessons, and their opinion about the teacher support materials. Other areas of attention during the interview included teachers' perceptions of what they had learned, difference between the observed lessons (on the topic of *Materials*) and their 'normal' lessons, learner-centred teaching and other relevant questions. See appendix 6.10 for the interview schedule.

Student questionnaire

To find out about students' perceptions of the lessons, they were asked to fill out a short questionnaire at the end of the lesson observations. This questionnaire focused on whether students had liked or disliked the lessons and whether they experienced any difference from the 'normal' lessons. It also addressed how difficult they had found the lessons, whether the level of the English (new medium of instruction in Namibia) used during the lessons had been a problem and what they felt they had learned. See appendix 6.11 for details of the questionnaire. A total of 165 questionnaires were collected from the students of the six classes where lessons were observed.

Student interviews

Observers held interviews with a total of 19 students after the lesson series. This happened with groups of students from each school (five groups of three students and one group of four). Teachers together with observers selected the students on the basis of proficiency in the English language, communication skills and initiative shown during the observed lessons. The interviews were semi-structured and a schedule is included in appendix 6.12.

Student test

At the end of the classroom observations students completed a short test. Students of the three Katima Mulilo schools completed the test at the end of the lesson observations. One class of students per school wrote the test, totalling 104 students (34 in school 1, 29 in school 2, 41 in school 3). The observer developed the test items, which covered all topics of the lesson series, and put them together in a test paper. All test items were of a short-answer type. The observer was present in class when the students completed the tests.

In the Keetmanshoop region, students wrote a different test. Three classes from a single school (school 4) completed the test after the classroom observations ended. A total of 71 students wrote the test (27, 23 and 21 students in the three classes). This test was a different and shorter test focusing on the first five lessons in the lesson series. The observer had developed the test items, but was not present when the tests were written. The test consisted of three multiple choice questions (first three questions) and two short answer questions, divided into sub-questions, resulting in a total of 15 items. The focus of the question was on the use of materials in relation to their properties, as well as on structure of polymers, covered in the first five lessons of the *Materials* lesson series.

Neither of the tests had been tried out, nor had it been part of a pre-test and post-test construction. The two tests are included as appendix 6.13 and 6.14.

6.8 Results of the field test

The *Materials* study developed support materials to assist teachers with the implementation of the new science curriculum. It aimed at supporting teachers in the areas of 1) lesson preparation, 2) subject knowledge, 3) teaching strategies, 4) student learning (see chapter 5). The new basic education curriculum in Namibia promotes a learner-centred teaching approach and the assumption had been that the use of the support materials by teachers for lesson preparation and execution would contribute to such an approach.

Important aspects of this approach include (MEC, 1993):

- Active involvement and participation of students in the learning process.
- Building on students' interests and experiences.

- Taking the students' existing knowledge and experiences as a starting point.
- Content should be relevant for students' lives.
- A practical approach to learning.

Data presented in this section, collected during the field test using the various instruments outlined in section 6.7.4, will focus primarily on these aspects. Results from the classroom observations are presented in 6.8.1 and 6.8.2. Section 6.8.1 provides a general impression of the observed lesson, and reports these for the three lesson components: start of lesson, body of lesson and conclusion of lesson. These impressions are based on the six teachers as a group. There were similarities in the way they executed the lessons, but there were also differences. Therefore, in the section 6.8.2, classroom observations are described for the six teachers individually. The teacher experiences with the lessons and teacher support materials (through interviews and logbooks) are detailed in 6.8.3, while student experiences with the lessons (through interviews and questionnaires) are found in section 6.8.4. Section 6.8.5 discusses student learning.

6.8.1 Classroom observations – general impressions

The observers came away with a positive impression of the observed lessons. Teachers were organised and prepared for the lessons. They appeared confident and competent in the lesson content, and communicated in an open atmosphere with their students. They used classroom aids (mostly blackboard, but also posters, in two lessons the overhead projector). Teachers were able to improvise where necessary and to discuss ideas that students brought forward.

Students were actively involved in many of the lessons. Lots of practical activities were conducted during the lessons. Many of these activities were introduced through discussions with the students and short demonstrations to illustrate the topic of the lesson. The discussions focused on students' ideas on the topic and activities, including how the activity was relevant in the daily lives of the students. For instance, a lesson on fibres and fabrics was preceded by an exploration of the materials used in the students' clothes. One student was asked to take off his (smelly) socks to see what material they were made of. Students were asked to provide examples of materials used in the construction of students' homes. Teachers maintained a pleasant relation with their students. Teachers guided the activities by posing many questions to the students, whereby students were asked, and were given enough time, to formulate their answers. This was especially so for the start of the lessons and the body of the lessons in which the main activity was carried out.

Students were grouped for most of the activities. This was frequently done in a very practical manner with minimal disruption of the class. Students sitting close together generally put themselves together into a group. Only in some cases did teachers interfere, for instance to create a better balance in female/male composition, or to avoid that all 'the big boys' of the class would be together in one group.

Time was the biggest issue encountered in the execution of the lessons. Teachers ran out of time in many lessons. This lack of time seemed one of the main reasons for a hurried, inefficient or entirely omitted drawing of conclusions from the activities and connecting the results to the theory presented at the start of the lessons.

It was obvious that some of the teachers in the study used a teaching style different from their usual one. This proceeded better in some classes than in others. This was especially apparent in the beginning of classroom observations. Students in two classes were clearly not used to carrying out practical activities, and were waiting for the teacher to provide more information and show them how to do the activity. Teachers were not completely used to this new teaching approach either. In the first few lessons some of the teachers seemed to feel uncomfortable, but this got much better in the course of the lesson observations. The average scores in the sections basic teaching skills, learner-centred teaching and subject matter of the curriculum profile shows positive summary scores for all teachers (see table 6.11).

Table 6.11 *Average scores of all lessons for teachers T1-T6 **

	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
Basic teaching skills	66	81	74	89	70	91	**78**
Learner-centred teaching	70	71	81	94	72	84	**78**
Subject matter	76	69	71	90	59	96	**77**

Legend: * Scores as a percentage of the maximum possible score

The scores presented in table 6.11 are summary scores in the areas of basic teaching skills, learner-centred teaching and subject matter averaged over all lessons per teacher, as well as the average of all teachers in these three areas (last column). The scores show large differences between teachers. Teachers 4 and 6 score high in all sections and contribute for a large part to the high average scores. For at least two teachers there were rather large differences across lessons, and across different sections of the lessons. For instance, teacher 1 felt happier and performed better in lessons with a large chunk of theory. Teacher 3, on the other hand, was doing very well in conducting lessons with students involved in practical activities and group work (81%), but struggled with some of the more difficult theoretical aspects in lesson 5. Teacher 5 also struggled with the theory in some of the lessons (59%). Detailed scores for individual lessons can be found in appendix 6.15.

Some of the teachers (teacher 2 and 3 especially) tried to use the teacher support materials to the letter. They were successful in doing this, with minor adjustment, mainly in terms of time. Other teachers, especially the more experienced ones (teacher 4 and 6), used the broad ideas in the materials and successfully incorporated these in their lessons. They successfully combined a number of lessons in afternoon sessions so that they were a bit more flexible with time for the lessons. The lessons in the teacher support materials and in the curriculum profile were made up of three parts: the start, the body and the conclusion of the lesson. The next three sections look at teacher performance in each of those parts separately.

Start of the lesson

At the start of the lesson, all teachers seemed well prepared for the lessons that were observed as part of this study. In only one lesson (of teacher 3) were there problems with a malfunctioning overhead projector. All materials and equipment had been organised, and were available for collection by the students. Worksheets, posters, OHP transparencies were ready for use. Teachers were also prepared for the execution of the lessons; they never seemed to be at a loss what to do next in the observed lessons.

The general set-up of the start of the lesson was an introduction of the lesson topic and important concepts by way of a short inventory of student ideas followed by a short discussion and a short introductory practical activity, where applicable. All six teachers introduced the lesson topics (except the one lesson of teacher 3). Many times this happened by involving students (in 24 out of 29 lessons), often by asking them about daily life examples and discussing these. In about two thirds of the lessons teachers managed to use student ideas to link the lesson with the students' daily lives. In 15 lessons (out of 24), teachers illustrated the topic of the lesson by doing a short demonstration. An example of this was the use of a beer bottle to illustrate the use of glass because it is transparent, or the use of a rubber hose to illustrate its properties and the link to its structure. ('It is strong, doesn't stretch, but it is flexible. Now, how are the particles arranged in this material?'). Teachers especially managed to do this in the introductory lessons, which were simpler in terms of content. In only a few lessons did the teacher provided inaccurate (one lesson, teacher 3) or incomplete information (four lessons, teacher 3 and 5) to the students. In particular the lesson on the structure of polymers was problematic for these two teachers. In some cases the introductions to the lessons were very short and limited to the lesson title or an introduction of the concepts dealt with in the lesson. In lessons in which most of the time was taken up by a practical activity, the start of the lesson was used to introduce the practical. In only some lessons was homework checked (in 9 of 29 lessons) and discussed (7 out of 29), but sometimes this was because no homework had been given during the previous period (11times). In 25 lessons teachers made use of the blackboard (or other classroom aids) to illustrate relevant points during the introduction. Table 6.12 shows summary scores for all lessons per teacher, for the start of the lesson.

Table 6.12 *Start of lesson – summary scores for all observed lessons per teacher* *

	T1	T2	T3	T4	T5	T6	Average
Basic teaching skills	61	75	60	86	58	89	**72**
Learner-centred teaching	75	68	83	98	60	83	**78**
Subject matter	100	100	80	100	60	100	**90**

Legend: * Scores as a percentage of the maximum possible score

Body of the lesson

Practical activities typically took place in the body of the lessons, except for lessons, which were used to report on the results of the practical activities of a previous lesson, and to draw conclusions from these results (see table 6.6). Teachers had all materials necessary for the activity ready in all lessons, except in one lesson where the absence of enough markers delayed the activity. In contrast with the teachers in the try-out, only four classes used a worksheet for students during practical activities. Teachers maintained a positive learning environment during the activity in all lessons, responding positively to student questions and answers and stimulating less motivated groups (in 12 lessons).

Students were grouped for activities, practical activities or reporting sessions in 26 of the 29 lessons. This was frequently done in a very practical manner with a minimal of disruption of the class. Students who were sitting close together formed a group. In the class of teacher 1, big groups were created due to a (perceived) lack of materials and equipment. Teacher 3 in one lesson created big groups (because he only had few worksheets), in another lesson, he formed groups, but the lesson basically proceeded as a (well organised) plenary session. Teachers usually did not assign specific roles to group members. All teachers interacted with the student groups in all lessons where this was applicable (n=20), but the role of the teacher during group work varied. Some were moving in and out of groups, asking questions and giving advice. Other teachers were more distant, just keeping a check on progress. One teacher (teacher 1) needed to instruct students about many of the basic scientific skills, such as using a balance. As a result he was very involved and basically carried out the experiments himself, and causing the activities to take much more time than anticipated. Students also asked lots of questions during the activities. Students were given some degree of freedom when carrying out the activities in 17 (out of a possible 24) lessons. Only in two cases did a teacher provide incomplete or incorrect subject matter information.

Table 6.13 *Body of lesson – summary scores for all observed lessons per teacher **

	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
Basic teaching skills	75	93	89	94	86	100	**89**
Learner-centred teaching	63	72	75	96	92	93	**82**
Subject matter	63	75	75	83	58	100	**76**

Legend: * Scores as a percentage of the maximum possible score

Table 6.13 provides summary scores for all observed lessons per teacher, for the three components: basic teaching skills, learner-centred teaching and subject matter. Scores are all satisfactory, with teachers 4 and 6 scoring consistently above the average score of all teachers together (last column).

Conclusion of the lesson

In 17 lessons (out of 25) conclusions were drawn from the practical activities, almost always together with students. In four lessons, conclusions were carried over to the next lesson. In 21 lessons (out of 24) teachers summarised the findings of the activities. In a number of lessons there were opportunities to discuss discrepant results from experiments. This happened in six lessons by four teachers. In five lessons, discrepant results were not addressed, leaving an unsatisfactory feeling with students. Instead, teachers just stated what the correct results should have been. In seven lessons, students used their own methods for solving problems. In four of these lessons time was spent on discussing these methods afterwards. Teachers referred back to the introductory theory in 17 (out of 24) lessons.

Homework was given at the end of 21 of the lessons. This homework was only checked nine times, and discussed seven times (see start of lesson section). The conclusion part of the lessons scored lower on the curriculum profile than the other parts of the lesson (see table 6.14). Despite persistent time problems, teachers and students managed to clean up the classrooms by the end of the period in 16 lessons (out of 18).

The conclusion section proved to be the most challenging part of the lessons. Drawing conclusions from the activities was a part of the lesson with varying quality. Although the curriculum profile shows a reasonable number of lessons where conclusions were drawn at the end, this was often not done in a proper way. Time problems, because the activity took longer than was planned, resulted in very short periods of time left to discuss experimental results. Conclusions from the activities were often not more than a hasty summary of the experimental results. In some lessons, students were asked to complete tables of results from the experiments for homework, but it was not clear what had happened next with the results. For two teachers, the lesson on the structure of the polymers was too difficult for them, and connecting structures to properties of the polymers was therefore problematic.

Conclusions were therefore not drawn. Teacher 1 did not draw conclusions in the early lessons that were observed. In the last lesson, on soaps, however, groups of students reported their results and conclusions of a practical activity, after which the teacher, using posters prepared from the teacher notes in the support materials, linked the outcomes to the theory. Teacher 1 clearly went through a process of growth during the lesson observations. This was not so obvious for other teachers.

Scores for basic teaching skills were lower than in the other parts of the lesson, but still satisfactory. Summarising the activity or discussing methods used were not always carried out properly, often due to time problems. Relating the conclusions of activities to the theory was a weak point in several of the observed lessons.

This part of the lesson also gave the most problems as far as subject matter was concerned. The teachers were expected to provide theory for what was observed in the practical activity, and to link this back to the introductory theory. In this section, only two teachers kept up the high scores of the start and body of the lessons (see table 6.14). Teacher 4 and teacher 6 have high scores in this section, teachers 1, 3 and 5 satisfactory, while teacher 2 scores low in this section, mainly because unexpected results from student activities were often not addressed properly.

Table 6.14 *Conclusion of lesson – summary scores for all observed lessons per teacher* *

	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
Basic teaching skills	62	73	75	85	65	85	74
Learner-centred teaching	72	73	85	88	63	75	76
Subject matter	67	31	58	86	58	88	65

Legend: * Scores as a percentage of the maximum possible score

6.8.2 Classroom observations– individual teachers

This section provides details of classroom observations for individual teachers. The details are presented as a general description of all lessons together of each teacher followed by a classroom snapshot, providing a typical view window of one (or two) of the lessons of each teacher. The scores of the curriculum profiles of the individual teachers are presented in appendix 6.15.

Teacher 1

The classroom snapshot # 1 of teacher 1 is fairly typical for his lessons. He followed the suggestions in the teacher support materials closely. It was clear that the lesson execution was rather different from his usual lessons; the students were initially a bit at a loss about what to do. They were offered and should have taken the initiative, but were clearly not used to that; they were waiting for the teacher to come and tell them what to do. The teacher himself also seemed a little wooden during the first few lessons. This caused the activities to take much longer than was suggested in the teacher support materials. It is also clear that students lacked the most basic practical skills, such as using a balance to weigh samples of fabrics. Average scores on the curriculum profile of teacher 1 show an encouraging balance (table 6.11), with the higher scores for the last lesson that was observed (see also appendix 6.15). In the course of the lesson series, with both teacher and students starting to get used to the lesson format, things started to happen much more smoothly. A point of concern was the fact that grouping of students for practical activities was done in a haphazard way, without any supervision or control by the teacher. And so it happened that for one activity there were three groups of students, two consisting of eight students, and one group of 20 (!) students. All 20 students were gathered around three beakers and a thermometer trying to find something out about the insulating properties of various types of fabric. During the next lessons the groups remained very big, but the teacher had now assigned group leader roles to students who should coordinate the practical activity, and makes sure that all students had a chance to at least see what was happening during the activity. The group leaders were also responsible for reporting of results. In oral presentations at the end of the practical activity, groups (most of the time not more than three or four) reported the results to the rest of the class. This was so successful that the teacher decided to improvise and continue this practice in later lessons. The teacher, with a BSc qualification in physics, was at his best when it came to mastery of subject matter, and was able to pick up much of the unfamiliar subject matter outlined in the teacher support materials. For instance, in the lesson on soaps, the teacher consolidated the experimental findings by beautifully prepared posters (on the working of soaps), based on the teacher notes in the teacher support materials.

Classroom snapshot # 1

During the first lesson (on fibres and fabrics) the teacher seems a little wooden, mechanical and not completely at ease, although he manages quite well. For the first lesson (on fibres) he had prepared himself very well, collected various examples of fabrics (nylon threads, cotton on a reel, all sorts of clothes (T-shirt, woollen baby clothes, nylon socks, etc.). Various examples of local uses of fibres are mentioned, such as nylon fishing line and fishing nets familiar in Katima Mulilo and other villages along the Zambezi River. He introduces the main lesson activity through a short discussion whereby he introduces the concept of natural and synthetic fibres and asks students to contribute examples of these. Addressing the properties of fabrics, the teacher concentrates on the clothes students are wearing. Jerseys (wool) are warm and T-shirts (cotton) are cool.

For the activity the students are asked to divide themselves in 'small' groups, resulting in four groups of 10 students. Hand-lenses are distributed and there is one microscope available for students to inspect the fabrics. Groups rotate to make use of the microscope. Students are asked to draw the fibre structures of the materials they examine, but only one student seems to do this. All activities seem to take much longer than foreseen in the teacher materials. As a result there is no time for examining the fibre structure of newspaper. Nor is there time to round off the lesson in a proper manner. A discussion on similarities and differences of the various fabrics is skipped. Homework is given (draw the structures of the materials you saw under the microscope), but students have not taken note of it. In the end the lesson evaporates a little. After the lesson the teacher apologises for this. He has realised that loose ends have been kept hanging in the air.

The rest of this lesson took place during the next period (lesson 10a in the table), where the rest of the activity is carried out. The teacher provides additional information on weaves and knits. Part of the lesson is also about when to wear what type of clothes, and how that relates to their structures, e.g. nylon shirts rather than woollen jerseys on the sports field. It is a mixture of student activity and teacher-led activity. Teacher draws the conclusions from some of the activities. Teacher employs a questioning style, which is rather closed. He ends questions with the phrase *'isn't it?* The students are conditioned to answer *'yes'* to this. This creates the impression that there is a lot of communication between teacher and students, but in fact there is not.

The lesson took place in a barren classroom without any sort of poster or anything to liven up the learning environment. Several of the windowpanes are broken and the desks and chairs and stools look horrible. There is a blackboard and chalk.

Teacher 2

Teacher 2 had a primary education teaching certificate and twelve years of teaching experience, for a large part at upper primary level. She had not had any science beyond Grade 10, although as outlined in chapter 2, before independence many students used the Education Certificate for Primary as a second chance to obtain a matriculation certificate (Grade 12). The lesson described in classroom snapshot # 2 is typical for teacher 2. She usually stayed close to the suggestions in the teacher support materials, with success, but in this lesson she decided to deviate from the suggestion to have houses built as a homework activity. She felt that this was an important group activity, which can not be done at home, as the support materials suggest. She has a very good relationship with her students, and is especially sensitive to opportunities for girls during the lessons. Her good performance is reflected in her scores on the curriculum profile (see table 6.11). In several of her lessons, conclusions from practical activities take the form of a summary of the results of the activity. For example, the lesson testing the strength of bricks did establish who had made the strongest brick, but did not lead to an understanding of the relationship between strength and the amount of cement used in the brick. In at least two of her lessons, there were opportunities to discuss unexpected results from activities and to use these as learning opportunities (see table 6.14 for low scores in the conclusion section). For instance, the houses, which students had built in this lesson, were of different size and shape. Obviously that created problems for the experimental set-up. However, teacher 2 chose not to discuss these, in spite of the fact that the observer had discussed these issues with her. Obviously, she did not feel confident enough to take on this challenge.

Classroom snapshot # 2

The lesson starts with the rounding off of the activity of the previous lesson. In that lesson, students tested the strength of bricks. Teacher, together with students, completes a table of results on the blackboard, like the one in the teacher support materials. No real conclusions are drawn. The question which type of brick is the strongest, remains unanswered.

Teacher moves to the actual topic of this lesson: roofing materials. As the building of houses in this lesson is going to take lots of time, teacher keeps the introduction deliberately short. She probes students' knowledge on the use of materials to make roofs in Katima Mulilo. They can think of grass and corrugated iron.

Students have brought grass and the teacher has collected cardboard boxes and small pieces of corrugated iron. Teacher instructs the students to build houses with roofs of grass and of corrugated iron, both with and without ceiling. Each of these four houses is built by a group of students. Students go outside and form groups. One group of only girls complains about the fact that there are no boys in their group. Traditionally, men build roofs, women cut the grass. One boy joins their group, but the girls do most of the work. Different designs are built. Girls cut grass with an axe, they use a piece of Coke tin as a knife to cut the cardboard. The activity goes well into lunchtime, but the students do not seem to mind. They enjoy this activity. All groups take pride in building a nice house. Eventually, different designs result.

The next lesson, the insulating properties of the different designs are tested by putting them in the sun and reading the temperatures inside the houses every five minutes, for 25 minutes. Every group reads the temperatures of all houses.

Teacher's role seems rather distant, but the students seem self-motivated. Back inside the classroom, students complete a table like the one in the teacher materials. All students agree that thatch is the best insulator, and that ceilings make houses warmer inside. *'If it were you, which house were you going to build?* Teacher has a few more questions for the students: *'is grass waterproof? Is grass attractive? Is corrugated iron expensive?* The classroom discussion results in thatch as the preferred roofing material. Most students settle for a grass roof, because it is a good insulator, easy to get, and it costs nothing. But the question why grass is a good insulator is not discussed.

Teacher 3

Teacher 3 has a teacher training certificate from the Katima Mulilo College of Education, and science education not beyond the level of Grade 10. He has 16 years of experience, and has taught and is still teaching a variety of subjects, including geography and physical education.

The lesson described in classroom snapshot # 3 was typical for the lessons of teacher 3. He was very good in stimulating students during group work through his very easy way of communicating with the students. He acted almost as a friend, even though he had a firm grip on the class. He was especially good in organising and executing the practical activities. Also in class discussions he allowed the students lots of room for contributions. Students were happy to take the opportunities given to them. The result was very lively lessons with lots of student involvement through questions, answers and suggestions for solutions to problems. Teacher used a condom as a teaching aid on several occasions to draw attention to its existence and to introduce them as normal items accessible for everybody (outside the lesson he indicates that he often discusses issues related to HIV and AIDS with his students).

Classroom snapshot # 3

A large table stands in the middle of the classroom. A variety of objects have been put out on the table. A concrete brick, an old, but complete Bakelite telephone switchboard, a plastic hair clip, different pieces of fabric, a rubber ball, pieces of wood, bottles, a condom, tins, grass, pieces of metal, a ceramic cup, so on.

Teacher had made posters with the three questions guiding the topic (as suggested in the support materials and also made at the workshop). Teacher focuses on one material at the time, lifts it up and asks students to identify the material it is made of. For instance, for a beer bottle, students suggest that it is hard, but that it breaks rather easily. Students have no problems in coming up with properties of the materials. They are eager to contribute to the discussion, when teachers give them room to do so. They also have lots of questions, e.g. when teacher shows a condom: *'outside we call it a condom, but we should call it a plastic here?'* Another student helps out*: 'the wrapper is plastic, but the condom is made of rubber!'*

Teacher then divides the class in three groups, not clear for what purpose, and moves to the next activities about the materials found in a vehicle. In the next five minutes a short inventory of the materials in a vehicle appears on the board. The students then move outside to see whether they can find these materials in the vehicle that is standing outside, after having been told by the teacher to be quiet and not to disturb other classes. He moves around and guides students to the correct answers. He keeps good control of progress and cuts the activity at some points when it looks that most students have identified the necessary materials.

Back in class the students and the teacher make an inventory of all the materials they found in the car, where they are used for and what properties make it particularly suitable for this use. During this session, students have many good suggestions, e.g. metal of the body and engine parts: hard, but can change shape (malleable), ceramics on the spark plugs and rubber pipes for the cooling system, soft seats with fabrics *('not like home when you sit on a tractor'*). Sometimes teacher needs to guide students to the correct answers.

The teacher summarises the lesson by highlighting the relation of the use of materials and their properties.

Teacher 4

Teacher 4 has had an education in science up to matriculation level (Grade 12) and holds a higher education diploma (HED) for teaching at secondary level. She has 5 years teaching experience.

Her lessons on the topic *Materials* were all lessons with lots of student involvement and room for student ideas, practical activity and group work. She did not follow the teacher support materials to the letter, but had clearly understood the important concepts and how to deal with these. She combined essential parts of different lessons in several longer lessons in the afternoon. Hereby she stuck to the suggestions made in the teacher support materials to outline the three pillars of the topic (use-properties-structure) and the three guiding questions as the framework for the topic, and to use these as a basis for the activities.

By her own admittance she was very afraid that students would make noise when outside the classroom doing practical activities. She kept the time students were outside to a minimum, after which students (and teacher) reported and drew conclusions when back in the classroom. Her questioning of students seemed very careful. Always giving students enough time to answer and responding to student ideas. Her class had posters on the wall (which is not usually the case in Namibian schools), including the ones made during the *Materials* lessons. She made efficient use of homework to extend lesson time and to give students extra tasks to do. All her lessons contained an activity for the students, including the lesson on the different structures of polymers. This very theoretical lesson could easily have ended up as a lecture type of lesson, but she chose to stick to the suggestions in the teacher support materials and turn it into a student activity. Teacher 4 had been able to relate the conclusions from the activities in most lessons to the three questions guiding the topic. The high scores on the curriculum profile (see table 6.11) confirmed the very positive impression left by teacher 4.

Classroom snapshot # 4

The posters on the use and properties of materials created by students in the previous lesson are still displayed around the classroom walls. Teacher collects homework from last lesson. Teacher introduces the lesson by listing more properties of materials resulting in what the support materials calls 'general properties' (applying to all materials), then moves on to introduce the activity of this lesson, testing of materials. She used wood as an example of a material to illustrate the idea of the activity, and shows how to write the findings in a table (like the one in the teacher support materials).

Teacher responds to student ideas and writes these on a flipchart, repeats them and expands on them. She establishes the relevance of the activity to students' daily life by asking questions such as *'what do you look at when buying an object?'*.

Teacher explains that the testing of the different materials will take place at different stations lined up outside the classroom. Results will be put in a table like the one on the blackboard. Students are asked to copy this table in their exercise books. She has organised boxes with materials in them for each group to test. Students collect these boxes from the front of the class. Teacher instructs students how to deal with the dangers of hammering some of the materials (e.g. cover glass with a cloth).

In groups of four students, eight groups in total, students work efficiently and diligently at each station for only a few minutes. Teacher keeps a strict time schedule for the testing activities, as she is aware of the limited time available, but also to make sure that students will stay on task and not make noise, disturbing other classes.

Back inside the classroom, teacher guides the reporting session by focusing on differences between two specific materials (e.g. between ceramics and glass). She asks groups for their results of specific materials, and records these on a flipchart. Teacher also checks how the students tested the materials.

When the lesson ends conclusions have not been drawn, and therefore the lesson continues for a short while in the afternoon.

In the afternoon, teacher together with the students divide materials into those that shatter when hit, and those that don't. Teacher links these two classes of materials to ionic and covalent structures and provides a first introduction to structures of the classes. As suggested in the teacher support materials, she demonstrates that a salt crystal is hard but can be shattered.

She also addresses some results that seem different from what was expected, like a student who tore a piece of fabric by hitting it hard. At the end of the lesson teacher instructs students to read relevant pages from the textbook, as homework.

Teacher 5

Teacher 5 had just completed his Grade 12 examination and immediately afterwards took up a teaching job at his present school. He had not followed a teacher education course of any sort and he was not much older than his students. At the time of the *Materials* lesson, he had a teaching experience of about half a year.

Students were often noisy and restless in his class. This caused much time wasting as it took time to get students to start with their activities and to keep the students on task. This resulted in a time problem at the end of most lessons, as a result of which lessons had to be cut short. In some cases these lessons were concluded in the next period. The problem teacher 5 had with some of the theory of the topic (see table 6.11) resulted in some confusing lessons. After one particular lesson, the teacher decided to repeat part of it, to make sure that the students had understood the relevant concepts of the lesson. Despite problems of keeping order in the classroom, and keeping students on task, the teacher tried to maintain an open atmosphere in the class, and tried to involve students by asking them questions and by giving guidance during activities.

Teacher 5 provided theory for observed results from the activity and was able to refer back to the theory introduced at the beginning of the lesson, in about half of the lessons.

Classroom snapshot # 5

Teacher seems well prepared and ready for this second lesson of the materials topic. He walks into the classroom with plastic bags and a number of worksheets under his arm. The students are noisy when he enters. Teacher introduces the lesson by writing the lesson topic on the board: *Materials – Use/Properties/Structure*, and introduces the Science Walk for this lesson. He explains the concept that the use of materials is linked to their properties and these in turn to the structures of the materials. He refers back to the previous lesson when students explored the materials in the vehicle of the principal. Students had been very excited looking under the bonnet of the vehicle to see what kind of materials are used. Teacher shows a plastic bag as an example of materials that can be found around the school. He explains the use of the worksheet, without having handed these out to the class.

Today, the students are a little unfocused, it takes them time to get into this activity. Outside the classroom, students are looking around the school grounds for objects, materials, and so on. Teacher has used the worksheet from the teacher materials for this activity. He hands these out to the students before they go outside. Initially, they are noisy and restless, but they settle down later on. There is a lot of talking, not always to do with the assignment the students are given. A few did nothing other then sit in the sun and walk around. Teacher tries to guide students by making suggestions where to look for the different types of materials. *'What do you find in the toilet?'*, he asks them when they struggle to find an example of ceramics.

Back inside, student groups are asked to report on the uses and properties of the various objects they found outside. The teacher writes the answers on the board. The period runs out of time before conclusions can be drawn properly. Students are given lots of time to complete the worksheet, which they clearly need. Despite this, they are unable to finish it. And so, the teacher asked the students, in groups of two, to complete the worksheet as homework for the next period.

At the beginning of the next lesson, only two of the six groups of students hand in their worksheets. Without any comments, the teacher collects these.

Teacher 6

Teacher 6 holds a BSc in mathematics, and teaches physics and mathematics at his school. He has a secondary teaching diploma (STD) and six years teaching experience. Teacher 6 had already covered the *Materials* topic before the teacher workshops were conducted. However, he was impressed by the simplicity of the theoretical framework and felt that parts of the topic should be done again.

He was therefore able to combine the main ideas of lessons, as it was to some extent revision, and he focuses especially on the three guiding questions of the topic. He had students carry out the Science Walk. Students used the results to make posters of the materials, their uses and their properties. Every group did a presentation on one of the materials under review, resulting in a very lively discussion about the general properties of materials. The teacher had organised this lesson in the afternoon, to have some more time available if necessary. Throughout the lesson, he kept coming back to the three pillars and the three guiding questions. He thereby maintained a very positive learning environment, and students had no problems asking questions. Groups of students presented the results of activities. In all lessons this was followed by the teacher referring back to the introductory theory and the general theoretical framework of the chapter. In the lesson where students tested materials to see whether or not these would shatter, the teacher rounded off with the help of a prepared poster. The scores in table 6.11 confirm the very positive impression teacher 6 has left behind in the classroom.

Classroom snapshot # 6

The teacher has already covered this topic earlier on in the year, but is convinced that the approach to the topic as introduced at the workshop is much better and more focused than the approach he has taken.

This lesson starts late because of a time table change. A mere 25 minutes is available for this lesson. Despite the short time available, teacher effectively combines the first and second lesson in the support materials into one. As suggested in the support materials, teacher has put the three pillars (use-properties-structure) and the three questions guiding the topic on posters.

The posters are displayed at the front of the classroom. In a class discussion the teacher introduces the three pillars and the three guiding questions (what are the different properties of different materials?; what properties make a particular material suitable for a specific use?; How does the structure of a particular material give it certain properties?) and uses examples of materials to illustrate the ideas.

Teacher uses the example of a beer bottle (also suggested in the support materials) and asks students to describe what it is used for and why glass would therefore be a good material to make a bottle. Students enthusiastically contribute to the discussion and generally seem to enjoy the discussion. Teacher guides students in the discussion by asking precise questions, repeats and discusses student ideas, and if he feels that things are not clear, he does not hesitate to repeat a point or a question in Afrikaans to make sure that students understand it.

In groups of four, students do a limited version of the suggested Science Walk. They spend just under 20 minutes outside looking for objects around the school grounds. When they return back to the classroom, the lesson has come to an end. No conclusions are drawn in this lesson, but this is carried over to the next lesson.

The next lesson is organised as an afternoon activity so that there is a bit of flexibility how much time to use. Students use the list of materials they found during the Science Walk to create the posters suggested in the support materials. Each group gets assigned one specific material, and is asked to list uses, and properties that justify that use. There are not enough markers, so the teacher suggests to some groups to decide what to write on the poster and write this in their exercise books, and to copy this on the poster when the markers come available.

6.8.3 Teacher experiences

Teacher perceptions on the teacher support materials and the lesson suggestions were gauged by interviews held with the six teachers after the lesson series and logbooks that teachers kept of the lessons that were observed. Five of the six teachers returned the logbook.

Teacher interviews

- *Initial worries about the 'Materials' topic and how the teacher support materials helped to overcome these.*

Four of the six teachers indicated that they were a little apprehensive about the topic. They thought that it would be difficult, because of the new knowledge required and the lack of experience in teaching this topic. There were worries about how to start these lessons ('*the way to start was a problem*'), disciplinary problems *('some learners may not take part*'), the fact that it was a new topic made it difficult, and the availability of equipment. Teacher 6 had already carried out the topic with his class, but he felt that his original lessons had 'no direction'. Teachers 2 and 4, however, felt they had a fairly good picture by just looking at the chapter in the textbook (even before the teacher materials were handed out at the workshop). Teacher 2 also felt that she could teach it as it was about things that were familiar to her.

All six teachers felt that the workshop introducing the topic of *Materials* and the support materials had helped them to overcome their worries. '*It showed me the way I should start*' (teacher 5) and *'now that I had the teacher guide, I thought 'Materials' is something I will redo'* (teacher 6 who had already conducted the *Materials* lesson without teacher support materials). Teacher 3 indicated that the workshop and the teacher support materials had put them in the picture and he was happy to see all the students so involved in class. Teacher 4 felt that the support materials had provided the structure for the lesson that was missing in the textbook. She indicated that the support materials helped with the planning of the topic and the lessons: *'planning, that is what the teacher guide basically is, planning'*.

- *Lesson preparation - time needed for preparation*

All teachers said that the time needed to prepare for the *Materials* lessons was acceptable, but there is quite a bit of variation in what teachers felt about it. Two teachers felt that the materials shorten the time spent on lesson preparation, because *'everything is already there, from aims, procedures, the conclusions, everything is alright', 'it is already partly prepared'*. Two teachers spent more time than with other lessons because it was a new topic for them (but as time goes by it will take less time than it does now). The other two teachers indicated that the time required for preparation was more or less the same as with other topics.

- *How have the support materials helped to teach the 'Materials' topic in a learner-centred way?*

All teachers felt that the teacher support materials have helped them organising activities during the lessons using a learner-centred teaching style, especially the idea that students need to do the work themselves and the teacher is only a guide, was mentioned by five of the six teachers. Some specific comments made by the teachers include:
'... It has contributed a lot, guiding me on how to organise activities that the teacher can only be ... a sort of supervisor ...'. (teacher 1). '
'From the teacher guide I learned not to stand there like a pastor and preach' (teacher 3).

All teachers felt they had been successful in their attempts to adopt a learner-centred teaching style. However, teacher 5 said that English was a problem for many of his students, and that he needed to guide his students much closer than he had really wanted. He also felt that learner-centred teaching worked quite well during the workshop, but in class with students it was a different story. He indicated that he would have liked more information and guidance on conducting group work. Nevertheless, he found that the way the lessons were written up (start, execution, finish) had been very helpful especially for an inexperienced teacher like himself.

All teachers indicated that the teacher support materials had helped them to specify and achieve the aims of the lessons. One teacher said that he had not always been able to meet all objectives in the allocated time and had to carry the rest of the lesson over to the next period. Teacher 6, who had redone the topic, now had a clear understanding of what needed to be achieved during the lessons. Teacher 4 said: '*Well, apart from having the script in front of me with the theory I know exactly the aim of the practical so what I want to achieve or what I want the learners to, you know, to learn in doing the practical themselves.* '

Three teachers said that it was more or less possible to do the lessons in 40 minutes, although they realised that they had carried some of the lessons over to the next period. Two teachers would prefer double periods for almost all lessons because reading guidelines and instructions for practical work by students took a lot of time. Two teachers used afternoons for lesson, another teacher used lunch hour to extend one of her lessons. Two teachers swapped periods with colleagues to create double periods to have more time.

Despite some problems with the lessons (especially lack of time), for most teachers, the execution of the lessons had created a feeling of success. As one teacher said: '*Yes, the good part of this having the guide, after you finished the lessons it leaves a different feeling of success ….'*

Teachers mentioned that they liked all lessons *('because I can get the many materials concerned or I think we can collect some from the bush or from home. Yes, that is the good part of it')*. Teachers also mentioned specific lessons or lesson topics:

- Fabrics *('I didn't know there was something like polymers')*
- Cleaning materials *('because even myself before the lesson I did not know how soap worked')*
- Properties of Materials (the practical activities where students test materials by hammering them). *Interestingly, students didn't like this lesson too much.*
- The structure of materials, of the various plastics *('it tells me the reason behind the properties of plastics')*
- Brick making *('because the girls were at first scared, but at the end it turned that they can make better bricks')*

Teachers could not think of any lesson they did not like. Teacher 5 got a little bored with the repetition of the relation uses - properties over many lessons. Teacher 4, when pushed for an answer, mentioned the testing of roofing where she had only 4 houses resulting in big groups. She said she would correct this next time building more houses so that each group can measure temperatures of their own house.

- *Difference between the 'Materials' lessons and normal Physical Science lessons.*

All six teachers found that the *Materials* lessons were more practical than their usual lessons. Students did most activities themselves, unlike the usual lessons when teachers do more demonstrations. Teachers felt that students can learn from doing the activities themselves. *'They see what is going on, they start asking questions, why is this happening. But when I am doing it they say: "Ah, he will do it for us"', okay?'* Not too much teacher talk, *'you give them time to do the experiments and then you are just there to look what they have done'*. Teacher 4 referred to the many activities that were carried out outside, which wasn't easy but she tried to finish the practical work quickly and drew conclusions from the activities once the students were inside the classroom again.

- *Lesson content – relevancy and level of difficulty*

All teachers indicated that they found the content of the lessons very relevant. Mentioned as particularly relevant were brick making (students will want to do this one day when they built there own house), roofing and fabrics. One teacher of the Keetmanshoop teachers found the insulating properties of fabrics less useful and relevant in Keetmanshoop, '*when it's hot, it's hot!'*

Teachers were of the opinion that students could easily understand the lessons. *'It is something we come across in our daily life. So, it is very simple for people to understand',* and *'The teacher guide has given us a simple theory, a simple idea on a certain concept, which we can understand easily and then transfer it to the learners.'*

'Unlike lessons in other topics, they will understand these'. However, teacher 3 mentioned the theory lessons (with the structures of the different polymers) were very difficult. Teacher 5 repeated part of the same lesson (on structures of polymers) to make sure that the students would understand it.

- *Availability of materials, references to textbook, homework*

Although most of the necessary materials were found, it took a long time in some cases. The various fabrics were difficult to find. One teacher said it took her a full day to find all the fabrics. Corrugated iron was sometimes a problem, although the INSTANT Project stepped in some cases. One teacher replaced grass, which is not available in her region, by plastic sheets. Students were asked to bring materials from home, or were asked to find them in the bush or on rubbish dumps. Generally, teachers found it difficult to convince principals of the need to buy small items for their science classes.

Teachers indicated that they used the textbooks mainly as a resource for themselves. Students were asked to consult their textbooks only in case there were things they did not understand. Two teachers asked students to make summaries of sections in the textbook. One of those teachers complained about students not reading their textbooks even when asked to do so. Questions at the end of the chapter were only used when they were applicable. One teacher (who did the topic for the second time) said that he and his students did not quite understand the order of things in the textbook. The second time he did it with the help of the teacher support materials, he understood the structure of the chapter in the book, and was also able to explain this to his students. Another teacher referred to the textbook as supplementary learning and information after the students carried out an activity in class.

One teacher made it clear that giving students homework was not as easy as it seemed. Students often do not do it and are sometimes unable to do it, because they live far from school and walk long distances to and from school, they have no light at home. Afternoon homework sessions at school are often taken up by other activities such as sports.

Teacher logbooks

Five of the six logbooks were returned. The results below are based on these five logbooks. Teachers reflected in the logbooks on a total of 28 lessons. Teachers found most of the lessons very useful, average score 3.89 on a 4-point scale. Teachers also felt that the lessons ran rather smoothly (score 3.60), although some low scores for individual lessons were recorded. Teachers indicated that most of their lessons were kept within the time allocated in the teacher support materials, even though some teachers reported in their logbooks to have run into serious time problems (average score 3.47). Teachers furthermore indicated that the lesson aims were mostly met (3.73), after lesson time was extended to finish the lessons (see table 6.15).

Table 6.15: *General impression of lessons by teachers (n=5)*

Scores	**Average**	**Lowest**	**Highest**	
Not useful	3.89 *	3	4	Very useful
Many problems	3.60	1	4	Ran smoothly
Many time problems	3.47	1	4	Suggested time OK
Lesson aims not met	3.73	3	4	Lesson aims were met

Legend: * Scores on 4 point scale

Teachers reported that the teacher support materials had been useful during the preparation, for *all* lessons. The main reasons are summarised in table 6.16 below.

The time teachers spent on preparing the lessons ranged from 10 minutes for a lesson which was basically a session reporting on the activities in the previous lesson, to 177 minutes for the start of the module including reading up in the textbook and teacher support materials. The average preparation time for the 28 lessons was 66 minutes. This excludes one lesson of a teacher who reported that the preparation had taken her a full day because the fabrics she needed were so difficult to find.

Table 6.16: *Why teachers feel the teacher support materials were helpful in the preparation of the lessons (for 28 lessons)**

Why materials were helpful	Specific comments
Guide for planning of lessons (n=10)	'It gave me an idea of the Science Walk'; 'the planning of it – information'; 'Putting down exact aims that are not in the textbook';
Assistance with the use of materials (n=4)	'by guiding the different types of materials to use'; 'it guided me with the usage of materials'; to set up the materials and help with planning'
Ideas on activities and execution of lessons (n=6)	'In setting the activities'; 'I could use almost all the ideas'; 'all examples were indicated' ; 'helped the teacher in doing the activity'
As a resource (n=5)	'Teacher notes – that was provided'; 'as good reading resource material'; with information needed'

Legend: * Some lessons were not referred to by teachers

In all lessons teachers stated that enough information was provided by the teacher support materials to understand the intention and the set-up of the lesson, as well as the required materials. The few problems teachers reported with the preparation of the lessons all had to do with the availability of equipment (microscopes) and materials (fabrics, corrugated iron). All teachers agreed that the teacher support materials had helped them a lot with the preparation of their lessons. Some lessons were felt to be rather time-consuming, especially the one on fibres and fabrics.

When asked if the teacher support materials needed any specific changes, there were a number of suggestions, including that students should build their houses at school not at home, as students scatter after school, to allow them to work together. Specific changes teachers had made to the suggestions in the teacher support materials included the use of flat and rondavel-type roofs in the roofing activity, taking students outside for some activities, the use of different roofing materials and pointing out ceramics as insulators on telephone poles next to the school.

Teachers felt that lessons were very useful (25 out of a total 28 lessons) and easily understood by students (23 out of 28 lessons). One teacher reported that during group work not all students immediately understood what they were supposed to do. As a result, a lot of time was wasted. Additional comments on the activities included: '*It was interesting, because students discuss and ask themselves some questions and they do answers for themselves'; 'They* (students) *felt much comfort and called themselves young scientists'*. Specific problems occurred with activities in nine of the 28 lessons. These problems related to (lack of) time, class size, lack of clear directions for students, as well as specific problems with the (complicated) structures of the different polymers. One teacher suggested allocating more time to some of the lessons so that activities can be done in one lesson, and reporting and drawing conclusions in the next lesson. Another teacher saw the solution in better preparation and makes suggestions on how to improve her own performance *('By putting more effort into planning')*.

Teachers see their role during the activities in the lessons primarily as a guide of students with difficulties (mentioned for 23 of the 28 lessons), as an active participant (12 times) and an explainer of things not very clear to students (10). Specific comments by teachers on their own roles included: *'It is my duty as a teacher to assist the learners if they encounter any difficulties'; 'To direct and bring them* (students) *to their own conclusion'; 'Learners have to discover their own effects of hammering objects,'* and also *'Learner-centred approach - lead by example' or 'I summarise their findings'*.

Teachers felt that they did not meet the lesson aims in only three of the lessons. This was due to confusing outcomes of experiments (e.g. insulating properties of materials and the orientation of fibres in different fabrics). In 25 of the lessons teachers felt that the aims were met, especially after taking more time for completion of the lessons. Teachers rated students' participation in the lessons as active, independent and interested. Students were actively involved and enjoyed the lessons a lot, and teachers sometimes seemed surprised by the performance of the students (*'They even contributed some of the reasons why they like thatched houses, it is because it is the best insulator').*

Specific comments focused on group size, and the lack of materials resulting in groups that were too big *('More microscopes should be given to schools for learners to be very much actively involved in the activity'),* lack of time to properly conclude activities *('give learners more time for writing up their ideas, how they discovered their own materials').* Moreover, one teacher reported for two lessons that students were unclear about their roles during group work, wasting time as a result. Suggested changes to remedy some of the identified problems included more materials so that groups can be smaller, more time so that activities can be properly rounded off by reporting sessions, and writing sessions giving students enough time to formulate their own conclusions and ideas. Clearer instructions for students during group work would make it more effective.

Homework was given in 18 of the 28 lessons. Homework included completing activities unfinished during class *('They have to complete the rest of the Science Walk Worksheet'; 'Learners have to complete the table of Plastic correctly')* or a follow-up of classroom activities *('Learners have to draw up their own list of materials found in your home/hostel room').* In some cases, teachers asked students to bring materials from home *('Bringing up the fabrics for the next lesson').*

6.8.4 Student experiences

An inventory of student experiences was made by way of interviews with students and a questionnaire administered to students. A total of 19 students were interviewed in groups after the lesson series (five groups of three students and one group of four). A total of 165 questionnaires were collected from the students of the six classes where lessons were observed. The responses of the questionnaire and interview are grouped around 1) student experiences of the lessons and 2) the differences of the *Materials* lessons with the normal physical science lessons.

How students experienced the lessons?

Of the 165 students, 47 indicated that they liked *all* of the lessons of the *Materials* topic. Students referred to the activities and experiments they had carried out during the lessons, the relation to everyday life (knowing what to wear during the different seasons and how to clean them) and future activities like building houses. They had been more involved because they had carried out the activities by themselves. Typical comments included: '*I learnt something, by doing things; 'It was very understandable'; 'Lessons were well prepared'* and '*teacher was nice …'; Knowledge for every day life, simple and interesting'; 'explanation was clear'*.

In the interview students reiterated these views. Students from all schools felt that the lessons had been much nicer because they were more practical and easier to understand, not like those lessons where '*you need to remember the periodic table and all those'*. Teachers seemed better prepared for the lessons, according to students of two schools, and the way the lessons were conducted had made learning easy. Students of one school said they had paid more attention during the lessons. One student in Katima Mulilo felt that the lessons had encouraged him to start making his own house, as the skills needed for this (making bricks, thatching roofs) had been covered in the class. He went on to describe how he would go to the bush to cut poles for the roof.

All lessons in the lesson series were included in the students' list of favourite lessons. This list was topped by the lessons on 'Brick making' (23 times), 'Fibres and fabrics' (21 times, mentioned by two classes only), 'Testing roofing materials (building houses/testing houses/building materials' (16 times). The main reasons students gave for their choice include the fact that they think what they have learned is relevant for them in daily life, and the fact that they had been involved in the class activities. One student felt that the lesson, which dealt with ceramics, was the best because *'ceramic is made by us black people here in our region, Caprivi'*. Typical comments by students are shown in table 6.17.

Table 6.17: *Best liked lessons mentioned by students (n=152)*

Specific lessons	Comments
Fibres and fabrics (n=21)	'I learnt which clothes to wear, how to clean them. I understood the experiment and the classification' ; 'I learnt the quality of different materials'; 'nice group work and experiment'
Brick making (n=23)	'I am able to make bricks for in the future'; 'Learn how to make a brick; I had to do it by myself'; 'We learnt how to make bricks'; we were involved in the class'; 'I can make my own bricks and house in future; 'it was interesting'
Roofing/building materials; building houses (n=16)	'I'm able to build a good house'; 'I never build a house'; 'I understood the experiment'; 'I can make roofs, know which roof is a good isolator, you can build your own house'; 'It helped me to know which house is warm and which is expensive'

Students indicated that there were few lessons they did not like. However, they did not like the breaking of materials very much, 'because it is dangerous' (10 times). Some students (10) found the 'fibres and fabrics' experiments too complicated and too time-consuming.

How were the lessons different from the normal physical science lessons?

Students of five of the six schools indicated that the *Materials* lessons were different from the normal physical science lessons. Four groups of students indicated that their usual physical science lessons were almost exclusively theoretical: listening to the teacher and copying notes from the board *('in the normal physical science lesson it is so boring, but in the materials we were looking with the materials and experimented a lot').* At the most there would be a short demonstration by the teacher. Students from school 1 had not done practical work half way through the year in Grade 10, nor the year before in Grade 9.

Students from the classes of the two female teachers indicated that their usual lessons also had practical activities, but that the practicals in the *Materials* lessons had been easier to understand, and were more structured and better organised. There was also more discipline and cooperation during the activities. In addition, students from all schools indicated that the language used in the textbook and in the class during the *Materials* lessons had been simpler than in the normal lessons and easier to understand.

Students of three schools referred to the content of the lessons being different from the normal lessons ('*we did not need all this fancy chemicals, like acid and calcium chloride, we could use our normal things.*'). Instead, the lessons were about materials which you can use in everyday life. The lessons were about general knowledge (students from one school).

6.8.5 Student learning

Student learning was gauged in two ways. First, students were asked what they felt they had learned from the *Materials* lessons, and second, a student test was administered at the end of the observation cycle.

1. *What students felt they learned from the lessons and how this can help in daily life?*

Most students reported the things they had learned about the different kind of materials, such as about insulating properties of roofing materials, brick making and how they could use this knowledge at home. Table 6.18 summarises the main results for students from the six schools (S1to S6).

Table 6.18: *What students felt they learned (n=162)*

School	S1	S2	S3	S4	S5	S6	Total
Uses, properties and structure of materials	12	3	14	16	7	6	**59**
Building houses/testing roofs	7	19	-	4	-	1	**31**
Fibres and fabrics (insulation, stretching, ability to dry, identification)	18	11	-	-	-	1	**30**
Brick making	-	10	-	11	-	8	**29**
Cleaning materials (how to mix water and oil)	13	-	-	-	-	-	**13**

Legend: numbers in columns represent the number of times a particular item was mentioned in the student questionnaire.

When students were asked to describe what they had learned that could be of help in daily life, they mostly referred to the various topics in the Materials lesson series, such as knowing how to use the different materials at home, how to make bricks, how to clean materials. Table 6.19 gives an overview of the responses. There were also more general responses, such as 'telling people about the lessons', but also 'doing things for yourself' (n=1), 'things you can do for a job' (n=2). The latter two have been included in the category 'other'.

Table 6.19: *How can this help students in their daily lives (n=159)*

School	S1	S2	S3	S4	S5	S6	Total
Use of different materials at home (and examples)	8	6	15	8	-	2	**39**
Knowing how to build houses	6	5	7	3	-	4	**25**
Telling other people about the lessons	1	3	2	-	7	1	**15**
Knowing how to make bricks (for building houses)	-	3	1	9	-	2	**15**
How to clean materials and hands	14	-	-	-	-	-	**14**
Fabrics and fabrics (which fabrics to wear when)	3	5	5	-	-	-	**13**
Know how to make a roof	2	7	-	1	-	-	**10**
Telling other people about the lessons	1	3	2	-	7	1	**14**
Care taking (materials are expensive)	-	-	-	1	-	-	**1**
Other	2	2	3	2	-	2	**12**

Legend: numbers in columns represent the number of times a particular item was mentioned in the student questionnaire

2. *Student test*

- *Katima Mulilo test*

Students from the three Katima Mulilo schools (one Grade 10 class per school) that took part in the field test wrote the test. In school 1 a total of 34 students (21 girls and 13 boys) completed the test. In school 2 this was 29 students (14 girls and 15 boys) while 41 students in school 3 (20 girls and 21 boys) wrote the test. Table 6.20 shows test scores for the three Katima Mulilo schools. Overall scores include all test items for all students together. School 2 scored better (57.2%) than schools 1 and 3 (42.4% and 43.6% respectively). Average scores in school 2 for girls (57.9%) were similar to those for boys (55.0%). In the other two schools boys did better than girls.

If only those items covered in lessons that were conducted with observers in the back of the class are included in calculating scores (see table 6.20 for details), scores for school 2 continue to be high. School 2 average scores for this subset increased to 69.6% (overall) with similar scores for boys and girls boys (69.2% versus 70.9%). Schools 1 and 3 score slightly lower in this subset than in the complete set of test items.

Table 6.20: *Summary of test scores for schools 1, 2 and 3 (Katima Mulilo)*

	School 1	**School 2**	**School 3**
Test scores	*(n=34)*	*(n=29)*	*(n=41)*
All test items			
	Mean (SD)	Mean (SD)	Mean (SD)
Overall	42.4 (20.1)	57.2 (9.9)	43.6 (18.8)
Female students	34.5 (14.9) (n=21)	57.9 (10.3) (n=14)	35.5 (13.8) (n=20)
Male students	55.1 (21.5) (n=13)	55.0 (9.7) (n=15)	51.4 (20.0) (n=21)
Items related to observed lessons only			
	Mean (SD)	Mean (SD)	Mean (SD)
Overall	41.6 (21.7)	69.6 (11.1)	39.0 (20.1)
Female students	34.5 (18.5) (n=21)	70.9 (12.3) (n=14)	30.3 (13.3) (n=20)
Male students	53.0 (22.3) (n=13)	69.2 (10.2) (n=15)	47.3 (22.1) (n=21)

Table 6.21 shows more detailed scores of individual test items per school. It shows that the more theoretical items score low. A question on the test (item 1) involving putting materials in two categories (those that shatter and those that don't), a practical activity in one of the lessons, shows a score of 82.9% in school 3. However, a follow-up item (1d) relating the shattering to the chemical structure of the materials was, by contrast, answered very poorly (22.0%).

Question 2 (items 5-6): 2a-b score well, also by students have not covered these lessons. School 2 students score low on question 2c (item 7, on how to increase the compressive strength of bricks). They are the only class who had tested the strength of bricks. However, during the lesson, the relation between the strength of the brick and its cement content was not properly established (see section 6.8.2). Also factual knowledge on how cement is made (item 2e), is answered poorly (13-15%) by all students. Question 3 about the structures of different polymers (items 12-16), on the structure and properties of polymers, was not answered very well, especially not by the students in school 3 (who had covered that lesson in class, but where the teacher had problems with the theory). Question 4 (items 17-19) on fibres and the difference between natural and synthetic fibres is answered reasonably well by students from all schools. Question 5 (items 20-26), relating the use of materials to their properties, shows similar scores for all three schools.

Question 6 (items 27-31) is covered in the lessons of schools 1 and 2. Students score in these items are 72.4%-96.6% (school 2) and 38.2%-70.6% (school 1). Question 7, on the advantages and disadvantages of grass roofs, generally used in Katima Mulilo (items 32-36), in comparison with corrugated iron roofs, were well answered (69-90% by students in school 2), but also reasonably well by students from the other schools who had not covered the topic in class. Somehow, this might be considered to be general knowledge. Question 8 (item 37) was answered very poorly by all students.

Table 6.21: *Scores of student test for the three Katima Mulilo schools* *

Question	Item #	Lesson	School 1 (n=34)		School 2 (n=29)		School 3 (n=41)	
1a	1	2	73.5		100.0		82.9	✓
1b	2	2	14.7		69.0		36.6	✓
1c	3	2	38.2		37.9		24.4	✓
1d	4	4	23.5		17.2		22.0	✓
2a	5	6,7	88.2		100.0		73.2	
2b	6	6,7,13	79.4		96.6	✓	85.4	
2c	7	13	35.3		24.1	✓	26.8	
2d	8	13	5.9		37.9	✓	4.9	
2e	9	6,7	14.7		13.8		14.6	
2f	10	6,7	41.2		65.5		29.3	
2g	11	6,7	73.5		79.3		48.8	
3a	12	5	11.8		51.7		41.5	✓
3b	13	5	11.8		34.5		22.0	✓
3c	14	5	17.6		41.4		12.2	✓
3d	15	5	5.9		20.7		7.3	✓
3e	16	5	23.5		34.5		17.1	✓
4a	17	10	41.2	✓	37.9	✓	53.7	
4b	18	10	41.2	✓	62.1	✓	56.1	
4c	19	10	35.3	✓	55.2	✓	43.9	
5ii	20	3	64.7		34.5		61.0	✓
5iii	21	3	35.3		31.0		22.0	✓
5iv	22	3	58.8		55.2		56.1	✓
5v	23	3	61.8		55.2		63.4	✓
5vi	24	3	38.2		20.7		34.1	✓
5vii	25	3	67.6		75.9		63.4	✓
5viii	26	3	47.1		34.5		58.5	✓
6a	27	11	38.2	✓	72.4	✓	39.0	
6b	28	11	52.9	✓	93.1	✓	51.2	
6c	29	11	14.7	✓	55.2	✓	19.5	
6d	30	11	70.6	✓	96.6	✓	65.9	
6e	31	11	55.9	✓	96.6	✓	68.3	
7a	32	8,9	64.7		93.1	✓	68.3	
7b	33	8,9	50.0		93.1	✓	70.0	
7c	34	8,9	58.8		86.2	✓	51.2	
7d	35	8,9	47.1		75.9	✓	58.5	
7e	36	8,9	58.8		69.0	✓	61.0	
8	37	14	5.88	✓	0		0	

Legend: * Percentage scores per item per class
✓ items covered in the lessons that were observed

- *Keetmanshoop test*

In the Keetmanshoop region, three classes of school 4 participated in a different and shorter student test. There was no information collected on gender. Table 6.22 gives the summary test scores for the three classes.

Table 6.22: *Summary of test scores for classes 10A, 10B and 10C (Keetmanshoop school 4)* *

Test scores	**School 4**		
Class	10A (n=27)	10B (n=33)	10C (n=21)
	Mean (SD)	Mean (SD)	Mean (SD)
	44.4 (13.5)	48.3 (13.8)	45.4 (11.7)

Legend: * Percentage scores

The average scores of the three classes in the same schools have been calculated by averaging the total scores of all students in each class. The average scores of the three classes are all between 40 and 50%, an acceptable score in the Namibian context. Table 6.23 shows item scores for the three classes in the Keetmanshoop school.

Table 6.23: *Item scores of student test for classes 10A, B & C in one Keetmanshoop school* *

Class			**10 A (n=27)**	**10 B (n=33)**	**10C (n=21)**
Question	**Item #**	**Lesson**	*Score*	*Score*	*Score*
Q1	1	4	40.7	36.4	28.6
Q2	2	4	3.7	12.1	9.5
Q3	3	3	55.6	57.6	71.4
aA	4	5	11.1	12.1	9.5
aB	5	5	14.8	24.2	19.0
aC	6	5	48.1	63.6	33.3
bA	7	5	3.7	9.1	0.0
bB	8	5	3.7	0.0	0.0
bC	9	5	3.7	0.0	0.0
biia	10	3	88.9	97.0	85.7
b*ii*b	11	3	85.2	87.9	85.7
b*iiia*	12	3	63.0	69.7	81.0
b*iiib*	13	3	70.4	75.8	76.2
b*iva*	14	3	88.9	93.9	90.5
b*ivb*	15	3	85.2	84.8	90.5

Legend: * Percentage scores per item per class

In table 6.23 per item scores for all items in the test are provided. Items that test students' understanding of the use of materials in relation to their properties (items 3, 10-15, see table 6.23) all score well in the Keetmanshoop test. However, items related to the structure of polymer molecules (items 2, 4-9) score very low in all three classes. These Keetmanshoop results are in line with the results from the Katima Mulilo test. Items testing students' understanding on the use of materials related to their properties seem to have scored well, while those items having to do with bonding and structure of materials are answered rather poorly. In addition, some of the results of school 2 (Katima Mulilo) seem to confirm what was observed in class, namely that the experimental results were not properly connected to the underpinning theory. However, with the small number of students involved in the test, this can only be considered as a first hint in that direction.

6.9 Conclusions from the Materials study

During the study, designers had the opportunity to evaluate the practicality and effectiveness of prototype teacher support materials in the classroom for the topic of Materials. The design specifications, outlined in chapter 5 (table 5.1 in section 5.2.2) were used as a basis for the development of the teacher support materials. The results of the three cycles of design and evaluation of the materials show, within limits, that the teacher support materials are *practical* and *effective* in the situations in which they were used, i.e. in science classes in junior secondary schools in Namibia.

The support materials are practical

The field test suggests that the materials are *practical*. Observers recorded that teachers were quite comfortable with the use of the materials. Some teachers used the materials to the letter, while others used them as a broad guide, as a basis for executing their lessons. Most lessons proceeded smoothly, creating much excitement among teachers and students alike. A considerable increase in the practicality of the materials took place during the development of the teacher support materials in the cyclic approach of design and formative evaluation. Directed by the results of the earlier evaluation activities (especially the try-out), the designers had to rethink the focus of the topic in order to provide a proper link between the theory underpinning the topic and proposed practical activities in the lessons. The lesson suggestions in the support materials underwent changes (sometimes considerable ones) to accommodate shortcomings observed during lesson executions, teacher and student interviews and logbooks. In some cases, complete lessons were exchanged for other ones, e.g. introductory lessons in the original version of the materials (version 1.2) were completely removed and replaced by others. Version 3.1, used in the field test, seemed to pose very few problems to teachers, except for the lessons on fibres and fabrics.

Time required for the lessons remained problematic throughout the lesson series. Only one of the six teachers executed the lessons in the time allocated in the teacher support materials. Three teachers allowed themselves more time in some lessons by carrying over the conclusion part of lessons to the next period. Two teachers used bigger blocks of time in the afternoon and combined lessons. In such a way, the teachers created some degree of flexibility in terms of time for the execution of the lessons. Time is a continuous problem in the execution of the lessons, but teachers seem to address these in their own ways, depending on the circumstances they work in, and their own preferences.

The teacher support materials are partially effective

Effectiveness of the materials was gauged by looking at the effects the use of the teacher support materials had on the execution of the *Materials* lesson and the teaching approach teachers adopted. In addition, effectiveness in terms of student learning was checked by way of a student test.

From classroom observations, as well as from teacher and student questionnaire and interview data, it was clear that all teachers were well prepared for the lessons. They had a plan for all lessons with a start, body and conclusion, and seemed confident to take on the job. Most of the lessons were carried out with the teacher using a learner-centred teaching style, and employed lots of practical activities carried out by groups of students. There were group discussions and plenary reporting sessions. Teachers had left their usual dominant position (talking for most of the lesson), although not in every lesson. From interviews with teachers and students, it became clear that they had experienced the *Materials* lessons as rather different from the normal lessons. The lessons were more practical and better organised. In addition, activities had more structure than usual and students paid more attention. Students felt that teachers had paid more attention to them and that they were 'nice' to them.

What was observed in the classroom, but also what teachers and students indicated as different from the usual physical science lessons, leads to the conclusion that the teacher support materials have been *effective* in contributing to well organised lessons on a new topic in the Namibian syllabus. It also leads to the conclusion that the support materials have contributed to a learner-centred teaching style.

Although the curriculum profile indicates that most practical activities were rounded off by drawing conclusions from the experimental results, the way in which this happened left much to be desired in many lessons. In some lessons, drawing conclusions was not much more than a summary of the findings. Furthermore, it turned out that some of the experiments showed unexpected results. Rather than using this as a point of discussion, teachers often choose to ignore it, or even skip the conclusion part altogether. It was clear that some of the teachers were operating at the outer limit of their subject knowledge. They did not venture into insecure areas for fear they might lose credibility with their students. This obviously has had effects on the execution of the lessons. Homework was seldom used to consolidate and as a check of what was learned during the lessons.

From student questionnaires and student interviews it has become apparent that effectiveness, in terms of the students learning, is especially evident in areas that are close to them and that are based on their daily life experiences. For instance, they have come to an understanding that thatch is a better insulator than corrugated iron, and why that is. During the lessons they have practised skills that are useful for them in their daily lives, such as making bricks and building roofs. The results of the student test seem to confirm that students especially gained in the more practical areas, but that achievement at the theoretical level was rather limited. Surprisingly, the girls in school 2 did at least as well as the boys in the class, which is normally not the case in African classes. The fact that the teacher is female might have something to do with it.

Initial positive experiences

Teacher responses in interviews and in questionnaires indicate that they themselves have enjoyed the lessons. Reasons given by teachers for liking or disliking a lesson showed that teachers, themselves, were also learning from the lessons. The reasons given referred mostly to themselves, rather than to their students, except in one case where it is about how well students worked in the lesson. The lessons worked out well, had been well organised, were lively, and yet the students were well behaved. Practical activities, apparently new for some of the teachers, had worked out well; students were excited and had paid attention. Teachers were surprised by what students could do by themselves, were impressed by the questions and suggestions during the lesson. All in all, it had been a positive experience for teachers.

Feedback to curriculum developers

The Working Group had formulated as one of the main aims of the *Materials* topic to create a practical oriented topic especially for students in rural schools who have only limited access to equipment. The support materials have assisted achieving this aim. The theoretical basis for the execution of the lessons - uses-properties-structure of materials - seemed to have worked very well. Test scores indicate that students have understood the idea that the use of materials is determined by their properties. However, the link between properties and the structure of the materials appears to be rather more difficult for the students, in both regions. Schematic drawings of structures of polymers seem beyond comprehension for most learners, but also for a number of teachers, especially the ones without a basic subject knowledge. This manifested itself in the classroom of two teachers, and was also reflected in the test results in this particular area. The conclusion seems justified that part of the topic dealing with bonding and structure should be simplified. Or, if that proves to be difficult, it should be omitted altogether.

A second area of concern is the section on fibres and fabrics. Although high on the list of favourite lessons (of teachers and students), there appeared to be a large number of difficulties that made the execution of the lessons cumbersome and the results of the practical activities difficult to interpret. Preparation of the fibres lessons was time-consuming because it was difficult to find all the necessary fabrics. One teacher spent a full day on this. During the classroom observations, two teachers tried these lessons (two practical lessons and a lesson reporting results, lessons 11, 12 and 13) with their classes. The first lesson was hampered by the absence of a microscope. The alternative of a hand lens did not provide enough information to draw structures of fibres. This made the lesson not only less dramatic, but it made drawing conclusion about fibre structure difficult. The second lesson suffered from the fact that it was difficult to identify the nature of the materials students used for the test they carried out. (was it nylon, polyester, a mix of the two? Was it wool, or was it a wool-like material like acrylic? Was it cotton or was it something else?). Although testing the insulating properties of the materials worked well (in one school students used beer bottles as beakers), the results were erratic and created confusion among the students and disappointment with the teacher.

Time was a continuous concern during the execution of the lesson in the *Materials* lesson series. Both the time per lesson, but also the time needed to complete the topic as a whole. A minimum of 15 lessons (without time for revision and writing tests) is required for the topic. With four periods per week for physical science, this means that at least four weeks need to be reserved for the *Materials* topic. This seems quite a lot of time, in view of the number of other topics in the syllabus and the time available to complete these. There is therefore a need to shorten the topic. The lessons on fibres and on the structures of polymers seem first in line to be removed from the topic. Alternatively, one could consider taking out some of the more elaborate lessons of the topic (such as the ones on fibres), and deal with these as student projects, to be carried out as out-of-class activities in the afternoon. Such projects could also be used for continuous assessment at school. Such a strategy would provide impetus to an area in the curriculum that has up to now been underdeveloped.

Suggestions for the final version of the teacher support materials.

Specific issues to consider for incorporation in the final version of the Materials teacher support materials.

- *Worksheets*

During the try-out, teachers introduced worksheets to guide practical activities. These seemed to work well. During revision of the teacher support materials for a small number of lessons, worksheets were introduced.

Designers were ambivalent about the use of worksheets in the classroom. Firstly, worksheets easily lead to a (practical) activity being reduced to carrying out instructions and answering the questions as an activity on it own (cf. Prophet & Rowell, 1990). The worksheet becomes the activity. Secondly, not all schools in the rural areas are in a position to provide worksheets to all students because of lack of paper and duplicating facilities. Although rural schools do not always have the possibility to use worksheets, some exemplary worksheets were included in the support materials. It was observed that teachers in only four of the lessons used these for their lessons.

- *Clearer support for drawing conclusions*

Drawing conclusions was not always carried out in the effective manner. Teachers appeared to have problems with embedding the practical activity in the lesson aims. Practicals were in some cases treated as activities in themselves, not necessarily connected to the goals of the lesson. This has also been observed in other studies in the Namibian context (cf. Kapenda et al, 2001). To support this further in the teacher materials, a clear description of how the activities during the lessons contribute to achieving the lesson aims. Other areas of concern in this respect are the limited time available at the end of the lessons, and the subject knowledge of some of the teachers.

- *Support for consolidating learning results*

Suggestions for consolidating what has been learned at the end of the lesson need to be strengthened. This can be in the form of homework (even though homework seemed a regular feature in only some schools), at the end of the lesson, or at the beginning of next lesson. Such activities will focus on student questions (from textbook) and additional questions in the teacher support materials.

- *Discussion on the accuracy of test methods*

In some of the lessons there were possibilities to discuss the methods used during the practical activities, and especially the accuracy of these methods. E.g. the use of a 'class mass' in the testing of bricks worked well but also gave rise to comments about such test methods. Support for a discussion on the accuracy of the method used and suggestions for possible improvements of the method.

- *Clearer instructions for group size*

  To counter the formation of big groups (up to 10-15 students) during practical work, as observed in some classes, clearer directions in this area need to be included in the lesson suggestions.

- *List of materials and equipment required for the topic as a whole*

  Teachers indicated that they would appreciate an overview of all the equipment and materials required during all of the lessons.

These considerations have led to an adapted version of the design specifications (see table 6.24). These adapted specifications have been used in developing the final version of the teacher support materials (version 4.0) for the *Materials* lessons. See appendix 6.16 for a sample lesson of this version, and www.decidenet.nl/research/tsm_namibia.htm for the full version.

The results of the *Materials* study show that the original design specifications for teacher support materials remain a solid basis for the development of teacher support materials for science teachers in junior secondary schools in Namibia. To address the observed constraints and weak areas in lesson execution, and to incorporate some suggestions and requests from teachers, a number of additions and fine-tunings have been proposed to the draft design specifications formulated and tested in the *Scientific Processes* study.

Table 6.24: *Design specifications for teacher support materials for science teachers in Namibia*

Catalyst function	**Design specifications**
Support for lesson preparation	*Overview of all lessons in topic* ▪ introduction to the topic ▪ short description of all lessons ▪ **list of materials and equipment required for the topic as a whole** *General description of lesson* ▪ description of what the lesson will look like ▪ aims of the lesson; **very clear description of the purpose of the lesson, and how activities contribute to the lesson aims** ▪ references to resource materials and further reading; and/or inclusion of relevant pages from the textbook *Lesson preparation* ▪ possible difficulties during the lesson ▪ materials required during the lesson and possible alternatives if not available
Support for subject knowledge	*Subject content* ▪ factual information on (difficult) concepts ▪ possible student questions and answers
Support for teaching methodology	*Teaching strategies* ▪ concrete suggestions for the role of the teacher ▪ suggestions for grouping ▪ suggestions on how to hand out materials ▪ **exemplary worksheets to guide activities** ▪ sequencing of activities, including starting up and finishing of the lesson and suggestions for homework ▪ **suggestions for questions (and possible answers) to guide drawing conclusions from practical activities and connection to theory**
Support for checking learning effects	*Learning effects* ▪ suggestions for student activities, test questions, and homework to check learning effects.

Legend: adaptations to original specifications are shown in bold

Chapter 7
Discussion

Chapters 5 and 6 presented findings of the separate studies carried out as part of the MaC study. This chapter looks across the two studies at the findings of the MaC study as a whole, and reflects on these.
A short introductory section (section 7.1) summarises aims and research design of the MaC study. Section 7.2 reports on the main findings of the MaC study. Section 7.3 reflects on various aspects of the use of the development research approach in the study. Section 7.4 reviews the observed concerns and opportunities for the implementation of a learner-centred teaching methodology in the Namibian context. Section 7.5 highlights the results of the use of teacher support materials in similar settings in Botswana as well as the potential of such materials in other professional development scenarios.

7.1 Introduction

After independence in 1990, the Ministry of Education and Culture in Namibia started with an extensive programme of educational reform to remedy imbalances of the past. A new science curriculum was introduced, starting at junior secondary school level. The curriculum advocated a learner-centred teaching methodology, active involvement of students, experiences of students as the starting point of lessons and content relevant for the daily life of students. The INSTANT Project supported the Ministry of Education and Culture with the implementation of the new science curriculum in junior and senior secondary schools in Namibia. Its multitude of activities can be categorised in three main domains:

- organisation and execution of professional development activities for teachers;
- development of an infrastructure for regional support to science teachers;
- development of teacher support materials.

The Materials as Catalyst (MaC) study was set up in support of the third domain of the INSTANT Project, but eventually also affected the other two domains. The MaC study set out to formulate characteristics of materials, which could support teachers with the initial implementation of the new science curriculum in the classroom in Namibia. The INSTANT Project had been developing materials for some time, but the effectiveness of these materials and how they were used in the classroom was never investigated. It was realised that a more systematic approach to design and evaluation was necessary in order to get information about these issues. The study was conducted in conjunction with the INSTANT Project, the researcher being a member of the Project team. It was realised that the implementation conditions were far from ideal, though it was not completely clear at the start of the study exactly what these conditions were.

The study was executed as a three-stage trajectory consisting of a front-end analysis, a preliminary study (the *Scientific Processes* study) focusing on the design and formative evaluation of an early prototype, and the main study (the *Materials* study) focusing on the practicality and effectiveness of the materials. Results obtained in one stage were used as input in the next stage.

The front-end analysis resulted in preliminary design specifications, which were tested in the *Scientific Processes* study. Results of this study were incorporated and further elaborated in the *Materials* study.

The MaC study used a development research approach (Akker, 1999) for the development of teacher support materials. Design and evaluation of the materials took place in a number of cycles involving try-out, appraisals and field tests.

This chapter reports and discusses the main findings of the MaC study.

7.2 Main findings

The MaC study developed teacher support materials in two separate sub-studies, the *Scientific Processes* study and the *Materials* study (aimed at Grade 10). The first study tested preliminary design specifications for such materials (aimed at Grade 8), formulated on the basis of the front-end analysis. The second study used these preliminary specifications for further development of support materials (aimed at Grade 10) and formulated more definite design specifications. This section reflects on the main findings. Section 7.2.1 highlights the observed effects of the materials on the execution of the lessons, while section 7.2.2 focuses on the design specifications of the materials. Section 7.2.3 reflects on the development process of the materials. Section 7.2.4 looks at how teachers used the materials for the execution of their lessons.

7.2.1 Effects of teacher support materials

Execution of lessons

Both the *Scientific Processes* study and the *Materials* study draw conclusions to the effect that the use of the teacher support materials has led to well-organised lessons in the majority of cases. Teachers had a plan for the lessons and were well prepared for the lessons. Equipment, materials and worksheets (if applicable) were ready before the start of the lessons. In the Namibian context this is a huge step forward. Teachers felt that most of the lesson planning had already been done for them. Some teachers indicated that the aims and objectives formulated for the lessons were very helpful in understanding what needed to be achieved during the lessons. In addition, teachers mentioned that the support materials had been useful as a resource with extra information on the topic of the lesson.

During the start of the lessons, students were regularly involved in discussions reflecting on student ideas and student experiences relevant for the lesson and the activity to be executed. In many of the lessons, students working in groups, carried out practical work. Drawing conclusions from the practical activities was a part of the lesson that exhibited varying quality. In one classroom, groups of students reported their results and conclusions of a practical activity, after which the teacher linked the outcomes to the theory using posters prepared from the teacher notes in the support materials. In another class, because of shortage of time, no conclusions were drawn at all, but students were asked to draw conclusions by completing a worksheet as homework. In the next lesson, however, this homework was not checked.

The introductory lessons in the *Materials* study were relatively easy: a simple chunk of theory, a clear set of activities and conclusions to be drawn from these. Conclusions were drawn in the majority of these lessons. In more difficult lessons, this happened infrequently and not always properly. Connecting conclusions to original aims of the lessons and to theory was not always dealt with in a proper way. Kapenda et al. (2001) observed similar practices in the Namibian classroom, where practical activities seem to provide an enjoyable introduction to answering unrelated questions on a worksheet. Connecting the outcomes of an activity to theory dealt with in the (previous) lesson rarely took place.

The conclusion is drawn that the connection between the specific experiment and relevant theory needs to be further strengthened (see chapter 6). This has been addressed in the final version of the teacher support materials by formulating the lesson objectives much clearer and in more detail with a clear description of how the practical activities contribute to achieving the lesson aims. Follow-up research is recommended to see whether such a stronger connection in the teacher support materials would indeed achieve this.

Classrooms in the Namibia have been typified as places where students are silent and where the teacher is the dominant figure; chalk and talk is the usual teaching method (chapter 2). In both the *Scientific Processes* study and the *Materials* study, classroom observations showed a much less dominant position of the teacher; students were involved through group work and practical activities. Both teachers and students confirmed that student involvement in the lessons was one of the main differences between the lessons supported by the developed materials and their usual physical science lessons. Student also indicated that they liked the group work and the cooperation with other students, in some cases for the first time. They had paid more attention, their teacher had been better prepared, and had been 'nice' to them.

Content of the lessons

Both the *Scientific Processes* and the *Materials* topic were closely connected to local contexts. In particular the *Materials* lessons were different from the usual science lessons in the sense that they were highly contextualised. They highlight several interesting local practices and provide a scientific basis for them. As indicated by Kasanda et al. (2001), who focused on the use of everyday contexts in Namibian science classes, teachers' fear may be a reason for the absence of contextualised lessons, because of their limited content knowledge. However, during classroom observations in the *Materials* study there was no sign of such fear. Teachers, all of whom were using the teacher support materials for the execution of the lessons in the classroom, seemed confident in class. Students seemed to like the local contexts a lot. In only a few lessons (dealing with molecular structures of polymers), two teachers struggled with the content of the lessons. Girls seemed to be very involved in the experiments, and were not the usual submissive part of the class. In stead, they often took the lead and showed the boys how to do things. This was certainly the case in the classes with female teachers.

Students expressed a high appreciation for their local practices, which might not have been there in the beginning of the topic. As an example, the use of grass roofs was considered to be inferior by students in one of the classes, but after they had carried out the experiment on the insulating properties of grass, comparing it with corrugated iron, they reconsidered.

Student learning

Student tests in the *Materials* study showed that learning was especially present in relation to the understanding that the use of materials in daily life was related to the properties of these materials. In addition, students indicated that they had gained skills that would be useful at home, such as making bricks, building roofs and understanding what sort of materials to use for these activities. Preliminary results of a student test indicate that students have achieved well in the more 'practical' areas, such as comparing different roofing materials and understanding what properties warrant the use of certain materials. However, the more theoretical aspects of the lessons, such as relating the properties of materials to their chemical structures, were answered very poorly. There may be several reasons for the latter. First of all, some of the teachers found it difficult to teach this topic because of their own limited knowledge in this regard. Secondly, the theoretical aspects of the lesson involved an application of the topic of bonding and structure (a topic covered earlier in the syllabus). There is reason to believe that the topic was not dealt with very well, as almost all items in the test related to this topic were answered very poorly.

However, the Working Group in the Ministry had developed the *Materials* topic primarily for the purpose of providing opportunities for students in rural schools to do practical work (see chapter 6). This has been achieved.

Students have learned practical skills that are useful, such as making bricks, and testing their strength. Furthermore, students have come to an appreciation of the usefulness of certain local practices, such as the use of grass for building roofs instead of corrugated iron roofs. The *Materials* lessons have not led to increased understanding of how the properties of various polymers can be related to their structure. Obviously, here is room for improvement. One would hope that practical work would also contribute to concept development by the students.

7.2.2 Design specifications for teacher support materials

The findings of the MaC study reported in chapter 5 and 6, and discussed in section 7.2.1, have resulted in the formulation of adapted design specifications (see table 7.1).

Those specifications are largely in line with the initial design specifications as these were drafted in chapter 5. A number of additions have been made to address the specific circumstances observed in Namibian classroom. These include:

- a list of materials for the whole topic as part of the topic overview;
- exemplary worksheets in case these are not available in the student textbook;
- a description of how the practical activities in the lessons contribute to achieving the lesson aims;
- more support for drawing conclusions from practical activities.

Table 7.1: *Design specifications for teacher support materials for science teachers in Namibia*

Catalyst function	**Design specifications**
Support for lesson preparation	*Overview of all lessons in topic* ▪ introduction to the topic ▪ short description of all lessons ▪ list of materials and equipment required for the topic as a whole *General description of lesson* ▪ description of what lesson will look like ▪ aims of the lesson; very clear description of the purpose of the lesson, and how activities contribute to the lesson aims ▪ references to resource materials and further reading; and/or inclusion of relevant pages from the textbook *Lesson preparation* ▪ possible difficulties during the lesson ▪ materials required during the lesson and possible alternatives if not available
Support for subject knowledge	*Subject content* ▪ factual information on (difficult) concepts ▪ possible student questions and answers
Support for teaching methodology	*Teaching strategies* ▪ concrete suggestions for the role of the teacher ▪ suggestions for grouping ▪ suggestions on how to hand out materials ▪ exemplary worksheets to guide activities ▪ sequencing of activities, including starting up and finishing of the lesson and suggestions for homework ▪ suggestions for questions (and possible answers) to guide drawing conclusions from practical activities and connection to theory
Support for checking learning effects	*Learning effects* ▪ suggestions for student activities, test questions, and homework to check learning effects.

7.2.3 Reflections on the development process of teacher support materials

User involvement

The two sub-studies developed teacher support materials in different ways. The materials in the Scientific *Processes* study were developed with the help of INSTANT Project staff and the Ministry's curriculum developers as informal reviewers. There was no involvement of user groups in the development process. After the classroom observations and evaluation of the materials, the INSTANT Project organised a number of workshops around the country on the topic of *Scientific Processes*. During these workshops, the teacher support materials were used as a guide for activities. Teachers enjoyed the activities and the materials. They contributed lots of additional suggestions from their local culture, e.g. on how to measure length. As no more revisions of the materials were planned after the workshops, these suggestions could unfortunately not be included in the materials.

The *Materials* study incorporated the lessons learned from the development process in the *Scientific Processes* study. Users (teachers) were now involved from an early stage in almost all phases of development. This has been of utmost importance (cf. Nieveen, 1997). During the user appraisal, teachers reflected on the lesson suggestions in the support materials and contributed additional local ideas and suggestions for activities and lessons. This has especially improved the practicality of the materials. Furthermore, the suggestions of local practices and incorporation of these in the support materials increased the chances of achieving one of the goals of the science curriculum, i.e. to take the experience of students as a starting point for the lessons.

Teacher involvement in the development of the materials has proven to be beneficial to both the teachers themselves and the materials. The opportunity for teachers to reflect on the lesson suggestions in the support materials has led to better understanding of the essential parts of the lessons. Teacher participation in the development has led to an increased practicality of the materials. In addition, there was an increased feeling of ownership for the materials. As a result, the materials may have been accepted more easily and have been put to use more effectively with less undesirable adaptation during lesson execution.

Some time after the workshop the researcher visited several schools in the Katima Mulilo region to find out whether teachers who had attended the workshop, and had taken part in the user appraisal (see chapter 6), had actually used the support materials for their *Materials* lessons. By their own accord, they had used the materials extensively, because after their involvement in workshops and in the appraisal these were now considered *´our materials´* (as one teacher expressed it). Teachers´ sense of ownership of the support materials had increased through their involvement in the appraisal of the materials, and by the try-out of the lessons in workshops. They felt they had helped to develop them and somehow claimed ownership of them. To use these materials was somehow nothing else but natural for the teachers who had helped in their development. In the school grounds there was plenty of evidence that several of the activities suggested in the teacher materials had been carried out. Bricks, some broken, others still in one piece, as well as small houses covered with grass roofs formed silent pieces of evidence.

User involvement in the development of the materials seemed to have contributed to the use of the support materials by teachers for the execution of their lessons in the classroom.

In-service training activities

After the completion of the *Scientific* Processes study, teacher support materials were used in in-service activities. Teachers used the developed materials to reflect on the lesson suggestions and tried out activities. In the *Materials* study, the development of the support materials was *incorporated* in a programme of professional development. Ball and Cohen (1996) and Loucks-Horsley et al. (1998) have indicated that the use of new curriculum materials, and reflection on them during in-service training activities, is an effective way to come to an understanding of the changes in the curriculum and to change beliefs about teaching and learning. In a similar setting in Botswana (Thijs, 1999), curriculum materials designed using similar specifications, appeared successful as an organising element in professional development activities at workshops and peer coaching at school. The combination of in-service training and follow-up in schools (e.g. through peer coaching) guided by exemplary materials seems a promising professional development strategy.

7.2.4 Flexible use of teacher support materials

Deviation from lesson suggestions

Teachers in the *Scientific Processes* study executed the lessons more or less as indicated in the lesson suggestions in the support materials. All teachers carried the materials with them to the classroom, and consulted these regularly during the lessons to see how much time to spend on a certain activity, or to check what kind of questions to ask. There were deviations here and there; especially the drawing of conclusions was carried out in a less efficient manner. However, major deviations from the teacher materials only happened with two teachers. This resulted in all cases in undesirable adaptations to lessons consisting of less student involvement and more teacher talk.

On the other hand, in the *Materials* study, deviations from the lesson suggestions led to acceptable adaptations. Some of the lessons differed in the way they were executed, but teachers kept the essential parts of the lessons intact. For instance, teachers combined essential parts of two lessons into a single lesson stretching over a longer period of time in the afternoon, or changed the set-up of the lesson to accommodate additional group work of students.

Teachers who were observed in the field test of the Materials study used the support materials in different ways. On the one side were teachers who kept as close to the lesson suggestions in the support materials as possible regarding sequence of activities in the lessons, start of the lesson, and the body with activities (introduction, execution and drawing conclusions). Time constraints and limited subject knowledge sometimes prevented a complete *fidelity* towards the materials. At the other extreme, some teachers used the support materials as a broad guide, picking out the essential parts and incorporating these into *adapted* lessons to suit their needs and practical possibilities, in terms of time and equipment available. This group of teachers was able to combine several lessons into larger blocks of time, during afternoon sessions, without losing track of the essential parts of the lessons. Thus, much along the lines of the model for curriculum implementation provided by Snyder et al. (1992), two major patterns of use can be identified, *fidelity* and *adaptation*.

This difference in the way the lesson suggestions were used in the two studies might be attributed to the fact that the *Materials* lesson series were embedded in in-service training activities introducing the lessons (see section 7.2.3), whereas this was not the case in the *Scientific Processes* study. Furthermore, in the field test of the *Materials* study, the two teachers with the most solid training and knowledge of both subject matter and pedagogy were the ones adapting the lessons in an acceptable way. Teachers with limited initial training stuck, successfully, to the lesson suggestions in the support materials. The two teachers with primary teaching certificates, and the teacher who had just left secondary school, all executed the lessons to a large extent in accordance with the lesson suggestions. One teacher, with a degree in physics but without any teacher training, initially stuck closely to the lesson suggestions, but after a few lessons he felt confident enough to incorporate successful parts of previous lessons, thus capitalising on earlier successes. The two teachers in the try-out of the *Materials* study had been asked to adapt the materials as they saw fit, which they happily did. Obviously, these fall in the adaptation pattern of use. In the earlier *Scientific Processes* study, most teachers showed a large degree of fidelity towards the lesson suggestions, while two teachers who deviated from the lesson suggestions in a major and unacceptable way, delivered lessons with much less student activities and with lots of teacher talk. In the *Scientific Processes* study teachers had not been introduced to the materials in in-service training activities, as had happened in the *Materials* study.

The materials in the MaC study appear to have provided teachers with a degree of *flexibility* of use. Whether teachers appreciated and used this flexibility depended on the subject knowledge and pedagogical skills of the teachers, on the one hand, and whether the development of the materials was embedded in in-service scenarios, on the other.

Sometimes, concerns are expressed about the prescriptive nature of teacher support materials containing detailed lesson suggestions. Critics suggest that these materials could restrict teachers in the execution of their lessons and would not leave any room for teachers to improvise and use their own initiative. Based on the results of the MaC study, these concerns seem unfounded. The materials have been shown to offer enough flexibility for those experienced teachers who require this. At the same time, the detailed exemplary lessons with procedural specifications appear to provide enough support for novice and unqualified teachers to successfully carry out the lessons. As Wallace (2000) put it: *'Good materials provide the kind of on-the-ground support needed by teachers as they work behind the classroom door. Materials need to balance the need for structured lesson planning desired by novices against the flexibility appreciated by veterans'*. It appears that the teacher support materials developed in the MaC study provide this flexibility.

Teachers involved in the field tests in the two studies had indicated that using the teacher support materials was of great benefit to them. This benefit had not been immediately clear to them, but became especially clear after a few lessons. The presence of observers in the back of the class had provided the initial motivation to use the materials in the first place. It appeared that teachers needed a bit of convincing before they realised the benefits of using the materials. School-based support can provide the extra bit of stimulation necessary to achieve this.

Initial successful experiences

In both studies, teachers who used the support materials for the preparation and execution of the lessons were enthusiastic about the lessons. They indicated that they were surprised and impressed by the performance of their students. Students were equally enthusiastic about the lessons. They liked the way they had been involved in the lessons, and they were also happy that the content of the lessons was about things they knew about (rather than about fancy chemicals with difficult names). During classroom observations in both studies it was clear that teachers enjoyed the positive atmosphere in the class. A number of teachers in both studies started to incorporate ideas they liked from the lesson suggestions in other lessons. In interviews after the lessons, teachers indicated that they felt good about the lessons. (*'It gives a different feeling of success'*). When implementing new curricula, Gunstone (1995) indicated that 'experience comes before understanding'. The positive initial experiences of the teachers can therefore be seen as an important step towards continued implementation of a learner-centred teaching methodology.

In conclusion, in the context where they were used, teacher support materials providing procedural specifications for essential parts of the lessons, have shown themselves able to act as a *catalyst* in the initial implementation of the new science curriculum in classrooms.

7.3 The use of development research approach in the MaC study

As outlined in chapter 4, the MaC study used a development research approach. The primary foci of development research are the realisation of promising small-scale examples of interventions and drawing up methodological guidelines for the design and evaluation of such products (van den Akker 1999; van den Akker & Plomp, 1993; Richey & Nelson, 1996). This section reflects on the benefits of development research in the MaC study (7.3.1), the role of the researcher (7.3.2) and the cyclic approach to design and evaluation with the aim of improving the quality of the intervention.

7.3.1 Benefits of development research approach in the MaC study

The two sub-studies in the MaC study (*Scientific Processes* and *Materials* studies) resulted in practical and partially effective teacher support materials for these two subjects. In addition, the studies resulted in guidelines for future development and evaluation of such materials in similar settings. These outcomes of the MaC study are in line with the purposes of the development research approach: development of prototypical products and generating methodological directions for the design and evaluation of such products (cf. van den Akker & Plomp, 1993).

A development research approach was considered to be appropriate for the MaC study in view of the rapidly developing situation of education in Namibia. Just after independence from South Africa in 1990, there was not only uncertainty about the design of programmes to support the implementation of the new curriculum, but worse, the conditions in which such programmes were to operate were also very unclear. Van den Akker, Ottevanger and Plomp (1994) identified additional results of a development research in the Namibian context that could possibly address these problems.

Considered particularly important were:

- a better understanding of the local implementation conditions and problems teachers are facing, and
- an increase in expertise and professional growth of the various participants in the development process.

The MaC study has resulted in a promising intervention, and has provided guidelines for the development of future activities in similar settings. Results of the MaC study are in line with generally held views that implementation of a new curriculum requires a multi-pronged approach. Exemplary materials and materials development can thereby be an organising element which provides direction to in-service training activities, a support to teachers in their classrooms, and a possible guide for advisory teachers helping teachers at school level. The latter activity can also take place in the form of peer coaching activities of teachers together with colleagues (cf. Thijs, 1999).

The front-end analysis (context analysis and a study of the relevant literature) provided insight into the general areas of concern regarding the implementation of a new (science) curriculum and the constraints that were expected in the Namibian context (poor teacher qualifications and experience, the lack of resources in the schools). Classroom observations and discussions with teachers in schools (during try-out and field test) as well as at in-service training activities (user appraisal) during the MaC study have provided a clear picture of the local implementation conditions.

Furthermore, participating stakeholders (INSTANT staff, regional advisory teachers in the Ministry of Education, teachers) all benefited from their involvement in the development process. This was considered to be especially useful in light of the need for building local capacity in developing countries.

7.3.2 Role of designer, professional developer and researcher

The researcher had several roles in the MaC study. Apart from the role of researcher, there were also the roles of designer of the teacher support materials, and of professional developer. Combining these roles was at times rewarding, but also posed problems. One such problem was the conflict of researcher versus facilitator in professional development activities. During classroom observations there was ample opportunity to provide feedback to teachers on the lessons that were observed. These were excellent moments to support teachers in their development. However, for the purpose of the research it seemed better to just observe and see how the teacher would use the materials to help him or herself. Reality was not always so black and white, though, and the researcher did in a few cases assist teachers with the preparation of the lessons, and was involved in reflecting afterwards on some difficult parts of observed lessons.

The researcher was intimately involved in all aspects of the design and evaluation of the teacher support materials. There was the danger that the teachers participating in the studies would give socially desirable and overly optimistic reactions to the intervention because of the presence of the designer of the materials. Another danger was the possibility of drawing too positive interpretations of data collected from classroom observations, interviews and questionnaires. Triangulation of data sources, methods and of researchers provided measures to counter this (Denzin, 1978). Research assistants, who were relative outsiders to the INSTANT Project and Namibia, were, together with the researcher, involved in classroom observations, student and teacher interviews in both sub-studies and acted as critical partners during reflection on the various research data.

7.3.3 Cyclic approach to design and evaluation

The development of the teacher support materials in a cyclic approach of design and formative evaluation has provided designers with the opportunity to improve the quality of the materials for the particular situations in which they were to be used. The MaC study consisted of two sub-studies, which in turn were composed of different cycles or iterations. Designers were able to incorporate results of the evaluation activities of a previous iteration into subsequent versions of the materials, to be evaluated in the next iteration. In this way the design iterated towards a final product, its quality improved with each iteration, until further evaluation seemed no longer effective. Teachers made various suggestions for improvement of the materials by providing alternatives for lesson execution and suggestions about local practices. Observers recorded several areas in the lesson execution that needed more thorough and clearer support in the teacher support materials. The various smaller components were also helpful in putting varying emphasis on the different quality aspects at different stages of the study. Initially, the emphasis was mostly on validity and practicality of the teacher support materials, but at a later stage the emphasis moved to effectiveness of the materials. This shift in emphasis is another aspect of development research (van den Akker, 1999).

7.4 Reflections on learner-centred education

Both teachers and students confirmed what was observed in class: lessons using support materials were executed in ways different from the usual science lessons. There were lots of practical activities, more student involvement, group discussions, and reporting of results. However, the quality with which these activities were carried out left much to be desired. Several reasons can be identified. Section 7.4.1 details some of these and highlights measures taken by the Ministry of Education & Culture to attend to them. Section 7.4.2 reflects once more on Beeby's model of stages of development in view of learner-centred education in Namibia.

7.4.1 Concerns (in relation to learner-centred education)

Subject knowledge

In the lessons that were most demanding of the teachers in terms of subject knowledge, several of the unqualified or not properly qualified teachers seemed to be operating at the very edge of their abilities. Drawing conclusions was often carried out in a less effective way, as was discussion of discrepant results from practical activities. Some teachers chose to ignore this aspect completely. Instead, they reported to the students what the results from the experiments should have been. Teachers avoided venturing into unknown territories and as a result, this only happened in very few cases and only with the teachers who had the confidence to do so. This often frustrated learners as unexpected results in the experiment were left unexplained and eventually taken for granted. In such cases teachers were observed to state what the results should have been. Similar observations have been reported in Caillods, Göttelmann-Duret and Lewin (1997, p. 59) on schools in Malaysia: '… *When the experiments failed, many teachers would simply suggest to students that they observe another group to see what happened when the experiment worked well, without explaining why it might have failed in that instance.*'

More theoretical aspects of the *Materials* lessons were very demanding on some of the teachers. In particular the aspects dealing with bonding and structure of materials were beyond the capabilities of some of the observed teachers. The lack of subject knowledge has negatively affected the execution of some of the more difficult lessons of the unqualified teachers in the field test.

To attend to the problem of under-qualified teachers (those with limited subject knowledge), the Ministry of Education has put a programme in place to upgrade science and mathematics teachers at junior secondary level: the MASTEP (Mathematics and Science Teachers' Extension Programme) programme at the University of Namibia, UNAM. This part-time programme upgrades teachers to teach at senior secondary level, but while enrolled at the programme, junior secondary schools may benefit (after two intakes, 360 will have been upgraded). The in-service variant of the Basic Education Teacher Diploma (BETD), with presently 2300 teachers enrolled, is the other programme that upgrades junior secondary teachers for science (and other subjects). About 900 students have graduated from this programme so far.

Language

In many of the observed lessons, the limited knowledge of English (for many students the second or third language, after their own local language and Afrikaans) posed serious problems in the communication among students and between students and their teacher. Discussions of results and reflecting on possible solutions to problems in groups of students were often carried out in a superficial way. Much of this can be attributed to the students' lack of proficiency in English as the new medium of instruction in Namibia. It hindered the constructing of knowledge by means of communicating about it. Similar observations have been made by Gray (1999) and Prophet and Rowell (1990) in the context of science education in South Africa and Botswana, respectively. In the *Materials* study, one teacher in particular, switched from English to Afrikaans, if he felt that the students had not understood what he was saying.

In recent times, there is a new discussion on the language policy in education in Namibia. There is pressure to extend the number of years that students use their mother tongue at schools, certainly for the whole of primary school, but perhaps also for junior secondary school. In the Namibian context the arguments are that teachers (and students) '*find it difficult* *to develop lessons based on communication and interaction when they themselves lack fluency in English. This tends to demotivate teachers who may revert to teacher-centred lessons in which they feel more confident.'* (England & Lawrence, in Harlech-Jones (1998). At the time of independence the apartheid regime needed to be overcome. Afrikaans was closely related to that regime, and needed to be abolished and replaced (by English). A decade later this argument is no longer relevant, and there may be room for a language policy, which would support wider educational goals such as developing a learner-centred teaching methodology. Callewaert (1999) argues for teachers in the BETD programme to be trained to operate in both their native language and English as media of instruction. The implementation of a learner-centred teaching methodology would certainly benefit from the introduction of native language instruction.

Support for teachers at school

There was little evidence in the schools that took part in the classroom observations that other teachers in the school were also employing a learner-centred teaching approach. A walk along classrooms in the schools showed the usual picture of a classroom with a teacher talking to students, or writing on the board and students copying notes in their books. Teachers involved in the *Materials* study were basically on their own in the school applying a new teaching methodology. There seemed very little support in the department and in the school for teachers. School principals did not see support to teachers as their duty. They instead left the professional development of their teachers to outside bodies such as the INSTANT Project, Life Science Project and other donor-funded projects working in the Ministry. But provision of school-based support was only a minor activity of these projects. Principals would sometimes observe teachers, but only for the purpose of evaluating their performance.

Peer coaching, as an alternative to school-based support from external project staff, was not well developed at the time of the MaC study, but more recent reports have appeared indicating that such activities are now in operation, on a limited scale. Sismey (1998) describes peer-coaching activities as part of the staff development for secondary English teachers in the Caprivi. Mbamanovandu (1999) reports on peer coaching activities by Life Science teachers in the Windhoek educational region. They report mixed results as to the willingness of teachers to participate in peer coaching activities although teachers indicated that they found the activity beneficial. Similar results are reported from Botswana with senior secondary teachers of science and mathematics (Thijs, 1999).

Ability to reflect on lessons

Teachers, especially those with limited teacher training and limited subject knowledge, were hampered by the fact that they found it difficult to reflect on the lessons they had carried out, at least in the interviews after the lesson series. Often they felt that 'the lesson was OK', or 'just OK'. This was also apparent in microteaching sessions in workshops, although there the reason forwarded was that teachers were not very comfortable providing criticism to colleagues. Rowell (1998) observes in the Namibian context: *'In my conversations with teachers, I often ask what aspects of their teaching are giving them problems. To my surprise (and concern), the most frequent response is "Nothing. Only the materials are a problem." This suggests that many teachers do not engage in a questioning of their own practice.'* Cook (1998) argues for teacher reflection to play a larger role in learner-centred education in Namibia, and provides examples of how to do structured reflection carried out with students. In the Basic Education Teacher Diploma (BETD) programme (see also chapter 3) students have gone through a programme called Critical Practitioner Inquiry (focusing on evaluating learning environments in order to develop an action plan to support, remedy or bring about change (MEBC, 1996b). Experiences they have gained as part of this programme may make reflection on their own practice easier and more frequent. The hope, therefore, is that reflection on lessons (in a peer coaching format) becomes a part of newly graduated teachers' repertoire.

Swarts (1999) indicates that student teachers in the BETD programme show a greater appreciation of learner-centred education in theory than in their practice in the classroom. Teacher support materials with design specifications as used in the MaC study can help student teachers to overcome the activation barrier between theory and practice.

Resources

Most of the schools in the *Materials* study had very limited resources. Students had textbooks available to them, sometimes sharing with other students in the class. There was little sign of extra resource books for teachers to prepare their lessons. The departmental prep rooms were basically empty, with a few unusable and out-of-date chemicals on the shelf, bits and pieces of the science kits, provided by the INSTANT Project, strewn around. Teachers indicated that it was also very difficult to convince their principals that money was necessary for buying small items in the local store for use in science classes.

Role of practical work

The role of practical work in science lessons in Namibia has so far been ill defined. In the early days of the new science curriculum, learner-centred teaching was equated with 'doing practical work'. At the time, the goals of the practical work were not questioned. The prime concern was that students were involved in class. This view of practical work falls into the category 'to motivate, by stimulating interest and enjoyment' (Hudson, 1993). There were other more diffuse goals, such as a support in the development of concepts and teaching laboratory skills, but these were not elaborated much.

Tjikuua (2000) indicates that traditionally, under the previous curriculum before independence, the function of practical work was almost exclusively seen as an illustration of a concept. The new curriculum has introduced the notion of practical skills and along with that the assessment of such skills, as a component of continuous assessment. In practice it has proved to be difficult to organise this and very little has been achieved in this area. Teachers have continued to think of practical work in terms of concept practicals (Tjikuua, 2000). Kapenda et al. (2001) suggest that practical work is still carried out as an enjoyable activity without too much relation to the aims of the lesson.

In summary, several concerns have been identified during the MaC study as hindering a proper implementation of the new science curriculum. As indicated above, the Ministry of Education & Culture is addressing many of these concerns through several training programmes, both in-service and pre-service training programmes.

7.4.2 Opportunities (for learner-centred education)

In chapter 3 the question was posed whether a learner-centred teaching methodology was the most suitable for the circumstances in which science education in Namibia was taking place. It was observed, based on the context analysis (chapter 2), that the circumstances in schools and classrooms formed a very difficult backdrop for teachers to implement a learner-centred teaching methodology. In chapter 3 the Beeby/Verspoor 'stages of development' model (unskilled, mechanical, routine and professional) was introduced and reflected on in view of Namibia's poorly developed education system before independence. It was suggested that a more traditional teaching style would perhaps be more suitable in such circumstances, but with an open eye for possibilities to infuse learner-centred teaching methodology wherever possible (de Feiter et al., 1995; Guthrie, 1990). In view of the concerns discussed in section 7.4.1 above, this suggestion remains valid. The MaC study, however, indicates that the implementation of a learner-centred teaching methodology is far from impossible. The use of high quality exemplary materials is a strategy to assist teachers with the initial implementation of such a methodology in the classroom. However, support materials by themselves will not make a lasting impact. Additional continuous support to teachers in the form of professional development programmes, both at in-service training workshops and school-based support will be essential for successful implementation.

The development of education in Namibia after independence shows that there are no quick-fix solutions in educational reforms. During the first decade of independence, Namibia's education system has developed steadily. A variety of programmes (both pre-service and in-service) are further developing the teaching force. For unqualified science teachers, upgrading programmes, such as the MASTEP programme and the in-service BETD, remain necessary, as do professional development programmes for teachers.

7.5 The use of teacher support materials in other learning trajectories

The use of exemplary materials has not been limited to junior secondary science classes in Namibia. Teacher support materials with similar design specifications have been incorporated in other learning trajectories, or have the potential to be incorporated. Some of these are highlighted in this section.

In-service training scenarios in Botswana

Similar teacher support materials were used in Botswana in the framework of a professional development programme for science teachers (UB-INSET). In this particular setting, exemplary materials were developed focusing on innovative teaching approaches in physics and chemistry teaching at senior secondary level (Thijs, 1999). The materials appeared to be very effective for teachers in preparing for microteaching sessions during workshops. Such sessions practised the new teaching styles in secure but nevertheless realistic settings (including students from nearby schools). Teachers used the materials at school for peer coaching sessions with colleagues, some of whom had not attended the workshops.

Classroom observations carried out as part of the UB-INSET programme after the above workshops, showed that teachers hardly consulted the support materials for the preparation and execution of their lessons. These nevertheless involved lots of practical activities for students. Students predicted outcomes of experiments, carried these out, and discussed results, much in line with the lesson suggestions in the support materials used at the workshops. Teachers indicated that since the materials had done their work at the workshop to get the idea across; there was no need for them to consult the teacher support materials again. Classroom observations and interviews conducted afterwards confirmed this position. Important to note is that the science teachers in Botswana were all university graduates unlike most of the science teachers in Namibia (cf. Thijs, 1999). Although teachers showed the ability to implement a student-centred teaching methodology in their classroom, they indicated that it would be impossible to continue with it because it would not properly prepare students for their final examinations. This misalignment of curriculum and examinations has often been indicated as a hindrance to successful implementation of the curriculum in the classroom, also in developing countries (Lewin, 1992).

An organising element for teacher groups in Teacher Resource Centres

Teacher Resource Centres (TRCs) have become centres for teacher development in many countries in Africa. Knamiller (1999), analysing a small number of TRCs, has expressed doubts about their effectiveness in spearheading teacher professional development. Teachers seemed to make little use of the TRCs and the impact of TRCs on classroom practice seemed very limited. In Namibia, however, there are a number of very active TRCs (notably Ponhofi TRC and Ondangwa TRC), where teachers meet on a regular basis to discuss subject related matters and to draw up lesson plans for upcoming topics. For such groups of teachers, exemplary lesson materials and reflecting on these can be a starting point for their activities. Hoppers (1998) states that in Southern Africa, TRCs seem to have effectively developed as a conduit for centralised teacher supervision, professional development and the inspectorate. Instead, Hoppers argues in favour of TRCs as stimulating places for local initiatives in the area of educational change. The development of curriculum materials by groups of teachers in the TRCs can hereby be an effective component of such local initiatives and can address the problem observed by Hoppers that teachers have the freedom to *implement* the curriculum but not to *develop* it. Reflection on exemplary lesson materials such as those developed in the MaC study can be used as a starting point in such initiatives. In support of local teacher groups developing curriculum materials, the CASCADE-SEA programme, developed at the University of Twente (McKenney, in press), provides teachers with a software tool for such a task. The programme uses design specifications for the lesson plans similar to those formulated in the MaC study.

Support to teachers introducing ICT applications in their lessons

Small-scale projects supporting teachers with the incorporation of ICT applications in their lessons also make use of exemplary materials similar to those in the MaC study. Examples of such projects include the use of Micro Based Labs (MBL) in physics lessons of A-level teachers in Tanzania (Tilya, 2000) and the introduction of ICT in physics lessons in junior secondary classes of rural schools in Russia (CROSS, 2000). The latter project is particularly interesting as lesson plans are developed in a collaborative effort across the web. In this respect, Koszalka et al. (1999) suggest a format for web-based lessons that is succinct for experienced teachers, and provide step-by-step detailed instructions to novice teachers for conducting the lessons.

7.6 Conclusion

Teachers support materials designed and evaluated in the MaC study were used to support teachers with the implementation of the new science curriculum in Namibia. The materials with procedural specifications for essential parts of the lessons, have shown themselves to be an adequate support for teachers in the initial phase of implementation of the new science curriculum in junior secondary classes in Namibia. These materials help teachers to overcome the activation barrier that characterises the change to an innovative teaching methodology. Use of the materials in class has resulted – within the constraints caused by a poorly qualified teaching force, under-resourced and poorly organised schools – in well-organised and well-executed lessons. The use of the materials has provided teachers with initial successful experiences with the implementation of the new curriculum. This is seen as an incentive to carry on with the further implementation of the curriculum.

The development of teacher support materials in a cyclic approach of design and evaluation, involving teachers in the development process as early as possible, has resulted in materials that take the local conditions and the problems teachers face in the class, into account. Furthermore, the use of the materials, in in-service training activities as well as in the classroom, have been shown to be a learning experience for teachers.

The MaC study concurs with Ball and Cohen (1996, p.7) who suggest that materials be developed *'to place teachers in the centre of curriculum construction and make teachers' learning central to efforts to improve education, without requiring heroic assumptions about each teacher's capacities as an original designer of curriculum'*.

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Samenvatting

Docentondersteunend materiaal als katalysator voor science curriculumimplementatie in Namibia

Context van de studie

In 1990 verkreeg Namibië na jaren van strijd haar onafhankelijkheid van Zuid-Afrika. Onderwijs in Zuidwest Afrika, het huidige Namibië, was destijds georganiseerd langs etnische lijnen. Elke etnische groep had zijn eigen ministerie van onderwijs. Er bestonden enorme verschillen tussen wat de verschillende ministeries te besteden hadden voor onderwijs. Het onderwijs in Namibië maakte deel uit van het Zuid-Afrikaanse Bantu-onderwijs. In de praktijk betekende dit dat er een enorm verschil bestond in de kwaliteit van het onderwijs voor de blanke bevolkingsgroepen en de andere bevolkingsgroepen.

Na de onafhankelijkheid begon Namibië met een grootscheeps programma van onderwijshervormingen om de erfenis van het verleden uit te wissen. Onder de slogan *'Education for All'* probeerde Namibië toegang tot het onderwijs voor leerlingen tot 16 jaar te vergroten. Een omvangrijke curriculumhervorming werd in gang gezet, te beginnen met de onderbouw van voortgezet onderwijs. Daarnaast vond er een grondige hervorming van de docentenopleiding plaats.

Het nieuwe curriculum liet een rigoureuze ommezwaai zien in het denken over onderwijzen en leren. *Learner-centred* onderwijs deed zijn intrede. De dominante positie van de docent in de klas moet plaatsmaken voor een systeem waarin leerlingen een veel actievere rol spelen. De leerstof moet aansluiten bij en voortborduren op de belevingswereld van de leerlingen. Leerlingen moeten eigen verantwoordelijkheid nemen voor hun leren.

De implementatie van het nieuwe curriculum begon in de eerste klas van de onderbouw in het voortgezet onderwijs (klas 8) in 1991. De exacte vakken en Engels werden aangemerkt als prioriteitsgebieden. De implementatiecondities ten tijde van onafhankelijkheid van Namibia waren en zijn nog steeds verre van ideaal. Docenten waren zwak opgeleid, de organisatiestructuur binnen scholen was matig ontwikkeld, scholen waren nauwelijks voorzien van apparatuur en materialen om praktisch werk uit te kunnen voeren.

Tijd om de curricula voor de aparte vakken goed te ontwikkelen was er nauwelijks. Diverse donorlanden en donororganisaties ondersteunden de implementatie van het nieuwe curriculum. Het INSTANT (IN-Service Training and Assistance for Namibian Teachers) Project, uitgevoerd door de Vrije Universiteit in Amsterdam, met financiële steun van de EU, kreeg de verantwoordelijkheid voor de implementatie van de science-vakken. Het project organiseerde een scala aan activiteiten in de volgende drie gebieden:

- organisatie en uitvoering van nascholingsactiviteiten voor docenten;
- ontwikkeling van een regionale infrastructuur voor docentenondersteuning;
- ontwikkeling van docentenondersteunend lesmaterialen.

De MaC-studie – onderzoeksvraag en onderzoeksaanpak

Het INSTANT Project had vanaf het begin van zijn activiteiten in 1991 ernst gemaakt met de ontwikkeling van docentenmaterialen. Echter, het was onduidelijk in hoeverre en hoe docenten die materialen gebruikten in de klas, en wat precies het effect ervan was. Ook de context waarin de materialen werden gebruikt was niet altijd volledig duidelijk. De MaC (**M**aterials **a**s **C**atalyst)-studie, uitgevoerd in het kader van de activiteiten die het INSTANT Project organiseerde op het gebied van materiaalontwikkeling, richtte zich daarom op de vraag hoe materialen ter ondersteuning van docenten bij de implementatie eruit zouden moeten zien. Daarbij luidde de onderzoeksvraag:

> *Wat zijn de kenmerken van materialen die docenten op een adequate manier kunnen ondersteunen bij de initiële implementatie van het nieuwe science-curriculum in de klas?*

De aandacht spitste zich toe op drie kwaliteitsaspecten: zorgvuldige onderbouwing en uitlijning (validiteit), goede bruikbaarheid in de praktijk (praktisch bruikbaar), en leidend tot het gewenste resultaat (effectiviteit). De MaC-studie gebruikte daarvoor een ontwerpgerichte onderzoeksbenadering (hoofdstuk 4), met daarin drie te onderscheiden fasen: vooronderzoeks-, de pilot- en de evaluatiefase.

Vooronderzoek

Het vooronderzoek bestond uit een analyse van de context van onderwijs in Namibië (hoofdstuk 2), en een review van de literatuur met betrekking tot onderwijshervorming en curriculumimplementatie met een specifieke focus op in landen ten zuiden van de Sahara (hoofdstuk 3).

Resultaten van het vooronderzoek: zijn als volgt samengevat:

- Docenten staan vaak in hun eentje als het aankomt op de implementatie van een nieuw curriculum in de klas.
- De complexiteit en het extra werk ten gevolge van het nieuwe curriculum in de klas vormden obstakels voor de implementatie ervan. Het ontbreken van duidelijke richtlijnen voor docenten hoe het curriculum vorm moest krijgen in de klas leverde problemen op. Uit studies van het implementatieproces bleek dat er in de eerste jaren van de curriculumvernieuwingen in feite in de klas erg weinig veranderde.
- Slecht gekwalificeerde docenten, scholen die slecht zijn uitgerust en slecht georganiseerd, lesgeven met nadruk op feitelijk kennis, en een ingeslepen routine van het kopiëren van aantekeningen die docenten op het bord hebben geschreven in hun schriften, maken dat de mogelijkheden tot verandering niet al te groot ingeschat moeten worden.
- Docenten, maar ook leerlingen, lijken de voorkeur te geven aan traditionele lesvormen. Praktische reden daarvoor is dat docenten vinden dat die studenten beter voorbereiden op het eindexamen Daarnaast is er op culturele gronden een bezwaar tegen lesvormen die de autoriteit van de docent in de klas zouden kunnen aantasten.

Het vooronderzoek concludeerde dat docentenmateriaal een katalysator zou moeten zijn om docenten over de eerste obstakels (*activation barrier*) te helpen die zich voordoen bij de initiële implementatie van het nieuwe curriculum in de klas. De katalysator zou de volgende functies moeten vervullen: ondersteuning bij de lesvoorbereiding; vakinhoudelijke ondersteuning; ondersteuning voor didactische rol van de docent tijdens de les; en bij het zichtbaar maken van leereffecten bij leerlingen. Een belangrijk kenmerk van het voorbeeldmateriaal is de procedurele specificatie voor essentiële onderdelen van de lessen.

Deze functies zijn verder geoperationaliseerd en toegepast in een eerste prototype van voorbeeldmateriaal ter ondersteuning van docenten bij een lessenserie voor het onderwerp *Scientific Processes*.

Prototypefase

De prototypefase werd vormgegeven door de studie naar kenmerken van voorbeeldmaterialen voor het onderwerp *Scientific Processes (hoofdstuk 5)*. De onderzoeksvraag tijdens deze *Scientific Processes*-studie was:

Wat zouden kenmerken kunnen zijn van materiaal voor een adequate ondersteuning van docenten bij de initiële implementatie van het nieuwe science curriculum in de klas?

In de *Scientific Processes*-studie is door de onderzoeker een eerste prototype gemaakt van het docentenmateriaal op basis van de kenmerken zoals die geformuleerd werden naar aanleiding van de resultaten van het vooronderzoek, en gesprekken met curriculumontwikkelaars. Tijdens de ontwikkeling van dit prototype waren experts binnen het Ministerie en binnen het INSTANT Project betrokken bij de evaluatie. Het prototype is uitgetest met een tiental docenten in hun klas in twee verschillende regio's in Namibia.

De *Scientific Processes*-studie heeft geresulteerd in een bevestiging van de geformuleerde kenmerken van het prototype-docentenmateriaal. Duidelijk bleek de praktische bruikbaarheid van het materiaal. Het gebruik van het materiaal door docenten in de klas had ook positieve effecten op de lesuitvoering. Het ontwikkelen van het prototype zonder betrokkenheid van docenten is evenwel ervaren als een gemiste kans om de praktische bruikbaarheid te vergroten. De aanbeveling was dan ook om docenten in een vroeg stadium te betrekken bij de ontwikkeling van materiaal en tevens om het materiaal in te bedden in nascholingsscenario's, zodat docenten kunnen reflecteren op de lessen in het materialen.

Evaluatiefase

Op basis van de ervaringen opgedaan tijdens en resultaten van de *Scientific Processes*-studie werd de evaluatiefase opgestart met als onderzoeksvraag:

Wat zijn de kenmerken van materialen die docenten op een adequate manier kunnen ondersteunen bij de implementatie van het nieuwe science curriculum in de klas?

Deze fase werd uitgevoerd aan de hand van een studie naar kenmerken van voorbeeldmaterialen ter ondersteuning van docenten die het onderwerp *Materials* in de klas 10 implementeerden (hoofdstuk 6). De *Materials*-studie werd uitgevoerd in een cyclische opzet van ontwerp en formatieve evaluatie, waarbij de nadruk in eerste instantie lag op de praktische bruikbaarheid van de materialen, maar gedurende de studie verschoof het accent in de richting van het vaststellen van de effectiviteit van de materialen.

In de try-out van een prototype van het materiaal door twee docenten en hun leerlingen, werd de praktische bruikbaarheid van het materiaal getest. Docenten reflecteerden op voorbeeldmaterialen als onderdeel van nascholingsprogramma's. Zij probeerden ook de praktische activiteiten in de lessen uit, en gaven daarover feedback. Op grond daarvan vonden herzieningen van het materiaal plaats. De evaluatie van de effectiviteit van het voorbeeldmateriaal vond plaats in een veldtest, waaraan een zestal docenten uit twee regio's deelnam. Lessenobservaties, interviews met docenten en studenten, alsmede een vragenlijst voor studenten, leverden een duidelijk inzicht op in de effectiviteit van het voorbeeldmateriaal. Naast effectiviteit in lesuitvoering is ook gekeken naar effectiviteit in termen van wat studenten in de lessen hadden geleerd.

Resultaten

Materialen bleken in de klas praktisch goed bruikbaar. Daarnaast bleken de materialen ten dele effectief. Alle lessen waren goed voorbereid, alle materialen waren beschikbaar, de docenten gaven er blijk van dat ze wisten waar de lessen over gingen. Docenten en veel leerlingen gaven aan dat de geobserveerde lessen anders waren dan hun gebruikelijke science-lessen, vanwege het feit dat er meer praktisch werk uitgevoerd werd, dat studenten meer bij de lesuitvoering betrokken waren, en dat de lessen gingen over zaken waar ze wat aan hadden, thuis, en in hun toekomstige leven (over het maken van bakstenen in plaats van over het periodiek systeem). Het taalgebruik in de lessen was ook gemakkelijker, en de lessen waren beter te begrijpen (volgens leerlingen). Het gebruik van de voorbeeldmaterialen leidde in veel gevallen tot een lesuitvoering waarbij de positie van de docent veel minder dominant was dan gewoonlijk. De leerlingen waren betrokken bij de les middels praktische activiteiten, discussies over resultaten en plenaire rapportages van resultaten in de klas. Studenten gaven aan dat docenten beter voorbereid waren, en ook aardiger tegen hen waren. Een aantal docenten gaf te kennen dat ze hun percepties over wat hun studenten kunnen, in positieve zin hadden moeten bijstellen. Ze waren onder de indruk van wat hun leerlingen konden, en de vragen die ze stelden.

Het trekken van conclusies uit de resultaten van de praktische activiteiten bleek minder succesvol te verlopen. Waarschijnlijke oorzaken liggen in tijdsgebrek en een gebrekkige vakkennis. Daarnaast bestaat ook de indruk dat praktische activiteiten vaak werden uitgevoerd als op zichzelf staande activiteiten zonder dat er een directe verbinding gelegd werd met de doelen van de les.

Sommige docenten hadden grote problemen met lessen die veel vergden van hun vakinhoudelijke kennis (*Materials*-studie). Zij opereerden duidelijk op de toppen van hun kunnen, en de meer theoretische lessen vormden daarom een probleem, ondanks uitvoerige toelichting en ondersteuning in het lesmateriaal.

Resultaten van de leerlingentoets in een aantal scholen aan het eind van de veldtest in the *Materials*-studie laat zien dat opgaven over zaken dicht bij hun dagelijkse beleving over het algemeen goed gemaakt zijn. Daarentegen zijn opgaven over meer theoretische aspecten van het onderwerp (met name over chemische structuren en hoe die eigenschappen van stoffen verklaren) zeer slecht gemaakt. Daarnaast geven leerlingen aan dat ze een aantal vaardigheden hebben geleerd waarmee ze hun voordeel kunnen doen in de toekomst: bakstenen maken, dakbedekking aanleggen, en weten welk materiaal daarvoor te gebruiken.

Docenten waren enthousiast over de lessen in het voorbeeldmateriaal. De praktische opdrachten werkten goed, de lessen verliepen in een goede sfeer. Er ontstonden geen grote disciplineproblemen of chaotische situaties vanwege een slechte organisatie van de lessen. Studenten waren enthousiast over de lessen, en lieten dat ook blijken.

De hoop is dat dit soort initiële succesvolle ervaringen met de lesuitvoering er toe zullen leiden dat de docenten vaker dit soort lessen zullen uitvoeren. Op die manier kan het voorbeeldmateriaal bijdragen aan een beklijfbare implementatie van vergelijkbare lessen.

Conclusie

De conclusie luidt dat het voorbeeldmateriaal een adequate ondersteuning voor docenten is bij de initiële implementatie van het nieuwe science-curriculum in de klas. Het gebruik van het materiaal en reflectie daarop leidt tot een positieve leerervaring bij docenten. Het gebruik van het materiaal zal met name een positieve werking hebben als het ingepast wordt in scenario's voor professionele ontwikkeling van docenten, zoals nascholingsworkshops en ondersteuning op school door middel van *peer coaching* activiteiten.

Appendices

Lesson 2 Finding out about substances

What does this lesson look like?

In this lesson learners will observe a number of substances all very familiar to them, such as sugar, tea, coffee and other items from their homes. This is a hands-on lesson. A general outline of how substances can be different and how they can be the same will help learners to draw conclusions from their experiment.

What are you trying to achieve in this lesson?

At the end of this lesson learners will be able to:

- *distinguish between substances on the basis certain properties;*
- *create a table and enter results in a logical manner.*

Relevant pages in Grade 8 textbook

Page 2 (Activity 1A).

Lesson plan and timing

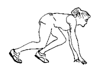
Activity	*Approximate time*
Start of lesson	5 minutes
Activity 1A: Finding out about things using your senses	20 minutes
Conclusions	10 minutes
Homework/Cleaning-up	5 minutes
Total approx	**40 min (one full period)**

2 Preparations before the lesson start

- *Bring to class:* sugar, tea, coffee, salt, sand, pepper, flour. Make sure there is enough for each group of four. Coke (or similar) bottles enough for one per group. Magnifying glasses if you have them.
- Each group will receive two substances only. There is not enough time to investigate all substances. One substance is sugar or sand (these two rattle in a Coke bottle). The second substance is one of the other sub-stances. A group can receive sugar and coffee or sand and flour and so on. Distribute the other substances evenly among the groups, so that in the end all substances will be investigated.
- Before the start of the lesson, put substances for each group out on the front desk on pieces of paper (cut a used A4 sheet in 8 pieces) with the name of the substances written on them. Put Coke bottles and magnify-ing glasses (if available) on the front desk also.

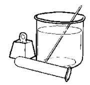
- Divide your learners in groups of four. This type of activity is ideal group work. Every learner can observe individually, but make sure learners discuss results within their groups and record a group decision in the table.
- Carry out activity 1A **for yourself** before the lesson. This will prevent surprises during the lessson. Think about possible problems the learners might have when they carry out the activity.

2 Execution of lesson



Start of lesson

- Introduce the activity on substances. Use a few examples to illustrate how different substances have different properties. Blindfold a volunteer learner and ask him or her to distinguish between a sample of sugar and a sample of flower by feeling with his or her fingers. Most likely the learner will feel the touch of sugar much harder than that of flour. Ask the learner how (s)he could tell the two substances apart.

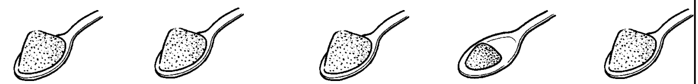


Materials every group needs for the following activity

- A teaspoon of each of the substances above;
- A coke bottle with top;
- A magnifying glass (if available).

Activity 1A

1. Divide learners in groups of four.
2. *One member* of every group collects the substances from the front desk. A teaspoonful of sugar or sand on a piece of paper plus a teaspoon of one of the other substances (only half a teaspoon in the case of pepper). **Supervise the collection of the substances fairly strictly to avoid confusion at the front desk.**



sugar salt sand pepper flour

2. Let learners observe colour, size, feel, smell, sound and shape of each of the substances they have collected. **Move around between groups during this activity. Guide and stimulate learners in carrying out the activity, but do not tell them the answers. Rather ask them questions and lead them to the right answer.**
3. Let learners copy the table on page 2 of their textbook in their exercise books.

Substance	Colour	Size	Feel	Sound	Shape	Smell
Sugar	white	very small	rough	quiet rattle	tiny crystals	none

Have them enter their observations in a table, like in the table above.

4. **Copy the same table on the board.**
5. As soon as learners have finished observing one substance they should write their observations in the table on the board. This table will be used when the results are discussed with the whole class.
6. Learners copy the results in the table on their exercise books.

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Conclusions

Discuss the results as they appear on the board. The table below shows possible learner answers. Answers depend on the samples, e.g. sand comes in different colours and different particle size. Tea can be brown or black or even green.

Substance	Colour	Size	Feel	Sound	Shape	Smell
Sugar	white	very small	rough	quiet rattle	tiny crystals	none
Salt	white	very small	a bit rough	very soft rattle	tiny crystals	none
Sand	brownish	small	very rough	rattle	sort of crystals	none
pepper	grey	very small	soft	no sound	powdery	itches when sniffed
flour	whitish	very small	soft	no sound	powdery	none

Possible questions learners ask or you might ask to guide the discussion:

1. Why do substances such as sugar rattle in a bottle while others do not? *[Answer: Because these substances are relatively hard]*
2. Do all crystals of a substance have the same shape? *[Answer: Yes, they have, although this will be difficult to see without magnifying glass. The crystals can be of different sizes though.]*
3. Do crystals of different substances have the same shape? *[Answer: No, crystals of different substances have different shapes.]*
4. A general conclusion could be that by doing investigations we can tell something about substances. We can tell them apart on the basis of their properties.

Finish of lesson

Ask learners to clean up a few minutes before the end of the period. Make sure they return everything to the front desk.

Homework

Ask learners to read page 4 on **mass** for the next lesson. Write home-work on the board.

Physical Science *for* Namibia Grade 8 - page 2

2 Chapter 1 Scientific processes

Activity 1A

PROBLEM: Find out about each substance by using your senses.

WHAT YOU NEED

Tin lids containing various substances
Magnifying glasses (optional)
Screwtop bottle

WHAT TO DO

Observe each substance carefully.

- What colour is it?
- What size is it?
- What does it feel like?
- What does it smell like?
- Does it make any sound (when you shake it in the bottle)?
- What shape is it?

These substances are all things that the teacher has collected either from home (like salt, sugar, tea and coffee) or around school (sand, leaves) or from the school supply of chemicals. Take care not to mix them up, they may be needed for other classes.

Another important scientific process is **recording**. This means writing things down in a neat and clear way. You should always record your observations. A good way to write down observations is to use a table. Make a table to record your observations.

Substance	Colour	Size	Feel	Sound	Shape	Smell
Sugar	white	very small	rough	quiet rattle	tiny crystals	none

Discuss which observations were the most important if you wanted to describe the differences between the substances.

Appendix 5.2a

Curriculum profile scores for 'Threshold' section, for teachers A-J

Threshold	**Teacher** A	B	C	D	E	F	G	H	I	J
Start of lesson										
▪ Teacher introduces lesson plenary	+	+	+	+	+	+	+	5/6	1/2	+
Activity										
▪ Teacher introduces the activity		+	+	+	+	+	+	5/6	+	+
▪ Teacher asks learners to form groups and carry out the activity	+ 3/4	+	+	+	+	+	+	-	-	1/2
Conclusions and End of lesson										
▪ In a plenary session conclusions are drawn from the activity	3/4	+	1/4	3/4	+	+	3/7	2/6	-	+
▪ Teacher gives homework	+	+	+	1/4	2/4	+	3/7	2/6	-	1/2

Legend:
+ indicates that the element has been achieved in all observed lessons;
3/4 indicates that in 3 of the 4 observed lessons the element has been achieved;
- indicates that the element has not been observed during any of the lessons
n/a the element is not applicable

Appendix 5.2b

Curriculum profile scores for positive and negative profile elements for the 'Start of lesson' section, for teachers A-J.

Positive elements	**Teacher** A	B	C	D	E	F	G	H	I	J
T. mentions important key concepts	+	+	+	+	+	+	+	+	+	+
T. refers to previous and (or) next lesson(s)	3/4	+	3/4	+	1/4	2/4	6/7	2/6	-	1/2
T. asks learners about their ideas on how to carry out the activity	1/2	2/3	-	+	+	3/4	1/5	1/5	+	-
T. rounds of the start o the lesson with a preliminary conclusion	3/4	3/4	1/4	3/4	1/4	2/4	2/6	-	-	1/2
T. illustrates lesson topic by doing a short practical activity	+	+	+	+	2/3	+	3/4	1/4	+	1/2
T. demonstrates the use of materials or equipment	+	+	-	+	+	-	3/4	-	1/2	-
T. mentions examples of everyday life related to the topic	2/3	+	1/3	+	2/3	3/4	4/6	1/6	-	1/2
T. manages to let learners ask meaningful questions	-	-	-	-	-	-	-	1/4	-	-
If necessary T. assists learners with the correct use of materials, equipment or execution of activity	n/a	+	-	n/a	n/a	n/a	n/a	-	+	n/a
T. discusses homework	1/3	1/3	-	1/3	-	1/3	2/6	-	-	+
T. writes on the board to emphasise important points and information	2/3	4/5	2/4	3/4	2/4	+	6/7	+	+	+
Negative elements										
T. do not check homework	2/3	2/3	-	2/3	-	-	3/6	3/5	-	-
T. reacts negatively to answer, question, action or behaviour of learners	-	-	-	-	-	-	-	-	-	-
T. ignores questions and (or) questions from learners	-	-	-	-	-	-	-	-	-	-
T. poses questions, but does not give learners the opportunity to think for themselves	-	2/5	3/5	2/5	-	-	-	-	-	-

Legend:
+ indicates that the element has been achieved in all observed lessons;
3/4 indicates that in 3 of the 4 observed lessons the element has been achieved;
- indicates that the element has not been observed during any of the lessons
n/a the element is not applicable

Appendix 5.2c

Curriculum profile scores for positive and negative profile elements for 'Activity/Body of lesson' section, for teachers A-J

	Teacher									
Positive elements	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
T. explains how to use the equipment and (or) materials	+	3/4	+	1/2	+	+	+	3/4	1/2	-
T. gives learners a certain degree of freedom to decide how to carry out the activity in their groups	+	4/5	1/4	+	+	+	+	1/3	-	+
T. physically mixes with groups of learners	+	+	+	+	+	+	+	n/a	n/a	1/2
T. observes learners use their materials, equipment or execute the activity	+	+	+	+	+	+	+	3/5	1/2	+
If necessary, T. assists learners with the correct use of materials, equipment or execution of activity	+	?	-	?	?	+	+	4/5	1/2	-
T. guides learners to carry out the activity	+	+	+	+	+	+	+	4/5	+	_
T. asks learners to report on the blackboard	+	-	-	-	-	1/5	2/6	1/6	-	1/2
T. stimulates learners to ask questions	-	-	-	-	-	2/4	4/6	2/5	-	-
Negative elements										
T. has not all of the necessary materials ready	-	-	-	1/4	-	-	-	-	-	-
T. reacts negatively to answer, question, action or behaviour of learners	-	-	-	-	-	-	-	-	-	-
T. offers learners solutions too quickly	-	3/5	2/4	-	-	1/4	1/5	1/5	1/2	-
T. ignores questions and (or) questions from learners	-	-	-	-	-	-	-	-	-	-

Legend:
- \+ indicates that the element has been achieved in all observed lessons;
- 3/4 indicates that in 3 of the 4 observed lessons the element has been achieved;
- \- indicates that the element has not been observed during any of the lessons
- n/a the element is not applicable
- '?' inconclusive: observers could not hear the matters discussed between students and teacher

Appendix 5.2d

Curriculum profile scores for positive and negative profile elements 'Conclusions/End of lesson' section, for teachers A-J

	Teacher									
Positive elements	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
T. asks some learners to give their answers (from activity)	+	+	+	+	+	+	3/7	3/6	+	1/2
T. encourages learners to draw conclusions	1/3	-	1/3	1/3	-	2/4	1/6	-	-	-
T. asks learners to report on their conclusions	-	2/3	1/3	1/4	2/4	2/4	2/6	-	-	-
T. learners to report on their methods	+	1/3	-	1/3	1/3	1/4	2/6	1/5	-	1/2
T. discusses methods used to carry out the activity and possible incorrect use of materials and (or) equipment (s)he observed	+	1/3	-	1/3	+	2/3	2/5	-	-	1/2
T. writes homework on the board	1/4	3/5	1/4	1/4	1/4	3/4	-	-	n/a	-
T. and learners spend a few minutes to get the classroom in order	+	+	+	+	+	2/3	3/4	2/4	1/2	+
Negative elements										
T. does not spend enough time on drawing conclusions	1/4	-	2/4	1/4	-	3/4	+	+	+	1/2
T. provides conclusions to learners too quickly	1/3	2/5	1/3	2/3	2/4	1/2	1/4	2/4	n/a	1/2
T. ignores questions and (or) questions from learners	-	-	-	-	-	-	-	-	-	-
T. reacts negatively to answer, question, action behaviour from learner	-	-	-	-	-	-	-	-	-	-
T. does not observe that me learners give a wrong answer	-	-	-	-	-	-	-	-	-	-
T. poses question to learner(s) but answers these himself or herself	-	-	-	1/3	1/4	-	2/7	-	1/2	1/2
T. explains homework not clearly	2/4	-	-	-	-	-	-	-	-	-

Legend:
- \+ indicates that the element has been achieved in all observed lessons;
- 3/4 indicates that in 3 of the 4 observed lessons the element has been achieved;
- \- indicates that the element has not been observed during any of the lessons
- n/a the element is not applicable

Appendix 5.2e

Curriculum profile scores for positive and negative profile 'Overall lesson information' section (teachers A-J)

	Teacher									
Positive elements	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Learners meet all objective(s) of lesson	+	3/5	2/4	+	+	3/4	6/7	1/6	1/2	1/2
T. improvises	+	n/a	+	+	n/a	+	2/3	-	-	+
T. presents on the board or overhead projector to emphasise important points of information or to explain	+	+	+	+	+	+	+	+	+	+
T. successfully carries out lesson in a way different from the teacher guide	+	+	-	+	+	+	3/5	-	-	1/2
T. gives learners a clear indication of what kind of behaviour (s)he expects from the learners	+	+	+	+	+	+	+	+	+	+
Negative elements										
The organisation during the lesson takes unproportionally much time.	1/4	-	3/4	-	-	1/5	-	2/6	-	-
The organisation of the lesson causes confusion or disorder	1/4	-	-	-	-	-	-	3/6	-	-
T. does not us the available time efficiently	2/4	1/5	+	1/4	-	1/4	5/7	5/6	1/2	1/2
T. misses overall plan for the lesson	-	-	2/4	-	-	-	-	+	-	-
T. has come to class not well prepared	-	-	3/4	-	-	-	-	+	-	-
T. presents information verbally, on the board or on the overhead projector which is not clear or not correct	-	-	2/4	-	-	-	1/7	4/6	1/2	-

Legend:
- \+ indicates that the element has been achieved in all observed lessons;
- 3/4 indicates that in 3 of the 4 observed lessons the element has been achieved;
- \- indicates that the element has not been observed during any of the lessons
- n/a the element is not applicable

Lesson 1 Revision of basic concepts

What does this lesson look like?

This lesson introduces the topic of 'Materials' and reinforces the following concepts dealt with in previous grades:

- chemical and physical changes,
- elements, compounds and mixtures,
- energy changes during chemical reactions.

The teacher will do a number of short demonstrations to illustrate the concepts.

What are you trying to achieve in this lesson?

At the end of this lesson learners will be able to:

- *understand the concept of physical and chemical change,*
- *know the difference between elements, compounds and mixture,*
- *understand that energy changes occur during chemical reactions.*

Relevant pages in Grade 10 Textbook

None, refer the grade 8 and the grade 9 textbooks

Lesson plan and execution

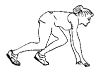
Activity	*Approximate time*
Start of lesson	5 minutes
Carrying out activities 1 and 2	25 minutes
Conclusion	5 minutes
Finishing the lesson	5 minutes
Total Time	**40 minutes**

1 Preparation before the lesson starts

- Learners should have carried out this activity in earlier grades. In this lesson a demonstration involving learners by asking them questions will be more efficient than groupwork.
- For the demonstration you need to prepare 7 grams of iron filings, 4 grams of powdered sulphur, a magnet, test tubes, a burner, and a hand lens.

1 Execution of the lesson

5

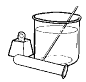


Start of lesson

- Explain to learners that the next topic of discussion will be 'Materials', which is covered in their textbooks in chapter 2.
- This topic deals with the properties of materials and tries to explain such properties by looking at the molecular structure of the material and the type of bonding present in the molecule.
- Explain to learners that before you start you would like to revise some key concepts which were covered in Grade 8. These topics are:
- chemical and physical change
- elements, compounds and mixtures
- energy changes during chemical reactions.

Invite learners to assemble around the front desk where you will carry out the demonstrations.

Materials required for the following activities:



- 7g iron filings and 4g powdered sulphur
- test tubes and burner
- magnet and hand lens

Activity 1

What are the differences between an element and a compound, and between a compound and a mixture?

a Iron and sulphur are both elements

1 Make a pile of iron filings and another pile of sulphur powder.

2 Ask a few learners to a handlens and to look carefully at the samples of iron and sulphur. Ask them what they see. *[Answer: Small particles of yellow sulphur and small particles of iron].*

3 Ask the learners what will happen when you ring the magnet close to each pile. *[Answer: iron filings will be attracted by the magnet, but the sulphur not].* Ask a learners to use the magnet.

b A mixture

1 Mix the iron filings and sulphur thoroughly.

2 Ask a few other learners to observe it with a hand lens. Can they still see separate particles of iron and sulphur? *[Answer: Yes, they will be able to see separate particles of iron and sulphur].*

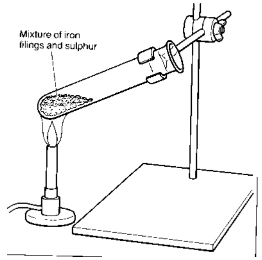
3 Ask a learner to hold the magnet above the mixture. What do you observe? *[Answer: the gray particles of iron filings are attracted by the magnet.]* Which element is attracted by the magnet? *[Answer: iron]*

continued on next page

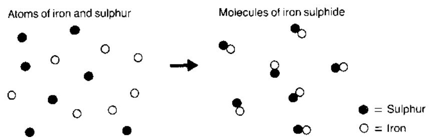
Activity 1 *continued*

c A compound

1 Put the mixture in a test tube.
2 Heat the bottom part of the mixture in the test tube.
3 Stop heating as soon as the mixture starts to glow. What happens to the mixture? *[Answer: It continues to glow]*
4 Ask a learner to look closely at the solid that has formed using the handlens. What does it look like? *[Answer: no longer separate particles of sulphur and iron]*
Does the magnet have any effect? *[Answer: No, the new compound which is formed is not attracted by a magnet.*



5 What are the main differences between the new substance formed and the mixture of Iron fillings and sulphur? *[Answer: colour and attraction by magnet].*



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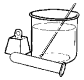


Materials required for the following activity:

- A4 sheet of paper
- matches

Activity 2

Physical and chemical changes

a Crumpling a sheet of paper

1 Show learners a sheet of paper.
2 Ask learners what a physical change is. *[Answer: a change which is temporary and can easily be reversed].*
3 Ask learners also about a chemical change. *[Answer: a change which is permanent and can not easily be reversed. Such a change results in new products being formed].*
4 Ask learners how they can use this paper to demonstrate a **physical** change. Possible answers include: 'Fold it', 'Crumple it', may be 'Tear it' (although strictly speaking correct, it will be difficult to get it back to its original form).
5 Ask the learner who gives the first or second answer above to carry out that example of a physical change. Also ask the learner to get it back in its original shape.
6 Ask learners how they to use the sheet of paper to demonstrate a **chemical** change.
7 If you have already shown the matches learners will come up with the suggestion to burn the paper.

continued on next page

Activity 2 *continued*

8 Burn a piece of the sheet to show an example of a chemical change.
9 Ask learners to describe the product formed. Is it a new product? Answer: Yes, it is. The black carbon-like product after burning is clearly different from the paper.
10 Could one get the paper back from the ash? *[Answer: No, not easily, this type of change is called a chemical or permanent change].*

5

5

Conclusions

- Discuss with the learners the following:

1 Elements can combine to form compound.
2 The properties of compounds are usually different from the elements of which they are made. Give other examples of this, such as water, a liquid, which is made of oxygen (a gas) and hydrogen (also a gas).
3 Mixtures can be separated fairly easily (by physical means).
4 Compounds can not be separated back to their elements.
5 Energy changes take place when a reaction occurs, e.g. the light being produced when paper is burned in the second experiment and the red glow in the first experiment.
6 Some changes are called permanent or chemical changes others are called physical or temporary changes. Can learners give examples of both types of changes seen during this lesson?

5

Finish of lesson

Spend time on cleaning up the lab.

Homework

- Learners should revise their notes on elements, compounds and mixture as well as on physical and chemical changes. (both Grade 8 topics).
- **Write homework on the board.**
- **Ask all learners to bring to class - for next period - any four items from their homes.** Suggestions are: a cup (plastic and ceramic), teaspoon (plastic and ceramic), a tennisball and racket, a walkman, a baseball cap, a basketball, a plate, a pair of sunglasses, and so on. These items will be used in the next lesson for the classification of materials.

Appendix 6.2 Curriculum Profile (Try-out)

Curriculum Profile Part 1 - Introduction to the Lesson
Teacher name: School name:
Lesson Name: Lesson Number:

A. Basic teaching skills

1.	Teacher introduces the lesson and series, if applicable	yes	no
2.	Teacher appears organized and ready to start	yes	no
3.	Teacher introduces/explains key concepts	yes	no
4.	Teacher summarises introduction with preliminary conclusion	yes	no
5.	Teacher illustrates lesson topic effectively	yes	no
6.	Teacher achieves this by doing a short practical activity	yes	no
7.	Teacher explains the use of materials/equipment	yes	no
8.	Teacher appears confident in subject area	yes	no
9.	Teacher appears competent in subject area	yes	no
10.	Teacher makes use of classroom aids (blackboard etc)	yes	no

B. Learner Centered Orientation

1.	Teacher relates activities to previous/future	yes	no
2.	Teacher asks learners for their own ideas re: activity	yes	no
3.	Teacher explains the relevance of	yes	no
4.	Teacher makes correlation to textbook (where applicable)	yes	no
5.	Teacher intervenes when students have problems	yes	no
6.	Teacher discusses homework (where applicable)	yes	no
7.	Teacher asks/answers homework questions	yes	no
8.	Teacher checks homework	yes	no

C. Classroom Management

1.	Teacher inteNenes too quickly	yes	no
2.	Teacher attempts to guide learners to conclusions/ideas	yes	no
3.	Teacher discourages inquisitive behaviour from students	yes	no
4.	Teacher ignores leamers'concems	yes	no
5.	Teacher attempts to include inattentive learners	yes	no
6.	Teacher poses questions but does not wait for answers	yes	no

Number of students in group today:
Number of students attentive:
Number of students in demo:
Number of students obviously not paying attention:

Curriculum Profile Part 2 • Body of the Lesson

A. Basic teaching skills

1.	Teacher introduces the activity	yes	no
2.	Teacher explains how to use materials/equipment	yes	no
3.	Teacher makes sure that materials are conveniently	yes	no
4.	Teacher stmulates less motivated groups	yes	no
5.	Teacher's un-preparedness detracts from lesson	yes	no
6.	Teacher reacts negatively to learners questions/behavior	yes	no

B.Leamer-centered orientation

1.	Teacher tells students what is expected of them	yes	no
2.	Teacher allows students room to choose their own approach	yes	no
3.	Teacher observes how leamers choose to approach activity	yes	no
4.	Teacher assists learners when necessary, but not immediately	yes	no
5.	Teacher guides learners via questioning, referral, etc	yes	no
6.	Teacher asks learners to report findings to class	yes	no
7.	Teacher encourages learners to ask questions	yes	no
8.	Teacher gives answers to learners too quickly	yes	no
9.	Teacher tries to understand learner problems/questions	yes	no
10.	Teacher readily grasps/handles learner problems/questions	yes	no

C. Classroom management

1.	Teacher groups learners for activity	yes	no
2.	Teacher physically mixes with students during activities	yes	no
3.	Teacher ignores questions/answers from learners	yes	no
4.	Teacher leaves classroom	yes	no
5.	Teacher effectively handles discipline	yes	no
6.	Teacher effectively handles timing	yes	no

Lesson body start time:
Lessonbody end time:

Cuniculum Profile Part 3 Conclusion of the Lesson

A. Basic Teaching Skills

1. 1n class wrap-up, conclusions are drawn from the activity yes no
2. Teacher discusses the methods used: correct and incorrect yes no
3. Teacher poses thought-provoking questions to learners yes no
4. Teacher spends too little time discussing activity afterward yes no
5. Teacher provides conclusions/answers too quickly yes no
6. Teacher reacts negatively to leamer inquiry yes no
7. Teacher doesn't notice some learners giving incorrect answers yes no
8. Teacher does not explain homework clearly yes no
9. Teacher gives specific homework yes no

B. Leanner Centered Orientation

1. The conclusions are derived from the learners yes no
2. Teacher asks leamers for their answers from the activity yes no
3. Teacher encourages leamers to draw conclusion(s) yes no
4. Teacher makes correlation to textbook (where applicable) yes no
5. Teacher asks learners to report on their methods yes no
6. Teacher explains significance of homework (re: activity) yes no

C. Classroom management

1. Teacher and leamers clean-up yes no
2. Teacher ignores questions/answers from learners yes no
3. Teacher asks learners but doesn't wait for response yes no
4. Teacher gives students homework as they are packing-up yes no
5. Teacher insures students'awareness of assignment (eg:board) yes no

Total length of lesson (minutes):

Curriculum Profile Part 4 Overall Impressions

A. Basic teaching skills

1. Teacher listens to learners yes no
2. Teacher uses media aids for further clarification yes no
3. Teacher's expectations of learners' behaviour are clear yes no
4. Where applicable, teacher has worksheets for students yes no
5. Teacher evidences a lack of organisation/preparation yes no
6. Teacher's un-preparedness detracts from lesson quality yes no
7. Teacher does not use available time efficiently yes no
8. Teacher appears to be confused about lesson itself yes no
9. Teacher makes use of classroom aids (blackboard etc.) yes no

B. Leamer Centered Orientation

1. Teacher summarises learners long answers yes no
2. Teacher gives answers to learners too quickly yes no
3. Is the classroom atmosphere conductive to learning? yes no
4. Is the room decorated? yes no

C. Classroom Management

1. Leamers meet overall objectives yes no
2. Teacher improvises yes no
3. Teacher improvisations are effective yes no
4. Teacher uses methods different from those in teacher guide yes no
5. Teacher's own methods are effective yes no
6. The actualization of the lesson is confusing/disorderly yes no

What is the classroom layout like?

What is the teacher's questioning like?

How does the room 'feel'?

Appendix 6.3 -Student Interview Plan

1. Of the activities you did this last two weeks, which was your favourite and why?

2. Teachers often have to choose how they will introduce certain ideas and concepts to their classes. Often there are two main parts: theory and a practical experiment which illustrates something about the theory.

   Which do you think helps you to understand better: learning the theory before doing a practical, or doing a practical and then following-up with the theory?

3. How have the lessons you did the last two weeks been different from your normal classes, if at all?

4. How do you feel about practical work, in terms of who actually does the experiments?

5. Do you think that the whole class understood these lessons, or do you think that there was some confusion and if so, where?

6. If you could have more of anything in your science classes, what would that be?

7. If you could have less of anything in your science classes, what would that be?

8. Can you think of anything new that you learned from these science lessons?

9. Do you feel comfortable asking your teacher for extra help? Why, why not?

10. Now that you understand my job here, do you have any comments, suggestions or other things you'd like to say which you think might be useful?

Appendix 6.4 - Student Questionnaire

Dear Students,

You were involved in some lessons on the topic, “Materials,” we would greatly appreciate your comments on the activities you did. Thank you very much for your cooperation!

1. How old are you? I am ……. years old.

2. Please list two things you liked about the lessons you did in the past two weeks:

a). ……………………………………………………………………………………………
……………………………………………………………………………………………

b). ……………………………………………………………………………………………
……………………………………………………………………………………………

3. Please list two things you disliked about the lessons you did in the past two weeks:

a) . ……………………………………………………………………………………………
……………………………………………………………………………………………

b). ……………………………………………………………………………………………
……………………………………………………………………………………………

4. Besides the video camera and two visitors, how were these lessons different from your regular classes?

5. Please name your favourite activity from the “Materials” chapter, and explain why it was your favourite: My favourite activity was …………………………………… because I liked …….
……………………………………………………………………………………………

6. Please name your least favourite activity from the “Materials” chapter, and explain why:
My least favourite activity was …………………………………… because I disliked ……..
……………………………………………………………………………………………
……………………………………………………………………………………………

7. Please write any other comments or suggestions you may have on the back of this paper.
Again, thank you very much!

Appendix 6.5 Overview and sample lesson of teacher support materials for the topic of *Materials* (version 2.1)

Lesson	Descripton of lesson
1	In the first lesson teacher and learners revise elements mixtures and compounds, physical and chemical changes as well as endo- and exothermic reactions. This is done by doing a number of experiments and getting feedback on the results.
2	Learners will do the science trail, classifying materials outside in the school grounds.
3 & 4	Identify common physical properties of each group as classified in as used in lesson 2. Learners will hammer and heat materials and observe the effect these have on them.
5	In this lesson learners will make bricks from cement and/or mud. These bricks will be used later on to test their strength.
6	Learners will investigate different types of plastic. The concept of the polymer will be introduced.
7	This lesson will investigate materials made from natural and synthetic fibres.
8 & 9	Bricks being made in lesson 5 will be tested for its strength.
10 & 11	In this double lesson learners will investigate materials used for roofs. Setting up an experiment they will test the insulating properties on different roofing materials.
12	Learners will investigate properties of materials used to make clothes. Both natural and synthetic materials will be looked at.
13 & 14	In these two lesson learners will investigate the insulating properties of different materials. A second investigation concentrates on the ability of materials to absorb water.
15	Soap and detergents are the topic in this lesson. Learners will carry out investigations in order to come to an understanding on how soaps and detergents work.

Lesson 2 — Classify materials according to their properties

What does this lesson look like?

In this lesson learners will observe in their environment were specific materials are used for. This lesson takes the form of a practical assessment with the learners *observing* different materials in a variety of different locations around the school. The teacher will organise in advance a 'science trial' around the school grounds, which a variety of objects (the principal's car, a bicycle, a window frame etc.) visibly labelled. Learners will be asked to describe how and what for the material is used. Learners should also try to state why this material used in this specific case and how this relates to the properties of the material. The skill assessed in the activity is *observing.*

What are you trying to achieve in this lesson?

At the end of this lesson learners will be able to:

- *classify materials as wood, metals, glasses, ceramics, plastics and fibres and others.*
- *identify examples of these materials in the local environment.*

Relevant pages in Grade 10 Textbook

Pages 16 and 17 (assignment 2A).

Lesson plan and execution

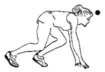
Activity	*Approximate time*
Start of lesson	5 minutes
Science Walk	30 minutes
Finish of lesson/Homework	5 minutes
Total Time	**40 minutes**

2 Preparation before the lesson

- Divide learners in groups of four.
- Prepare a worksheet for every group. This worksheet should have questions about the objects learners will investigate around the school. The materials of which the objects are made should fall in the following categories: Glass, wood, plastic, metal, ceramics (pottery) and fibres.
- A sample worksheet is included.

2 Execution of the lesson

10

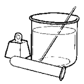


Start of lesson

- During this period there will be very little time for homework. Announce to learners that you will check and discuss homework at the beginning of next term.
- In our daily lives we use a great many objects. These objects are made of a variety of materials. We can classify objects in different groups on the basis of a common property.
- One way of putting the solids in groups is given on page 17 of grade 10 book (see table below). But there could be additional groups. Can learners think of any?

Glass	Wood	Plastic	Metal	Ceramics (pottery)	Fibres
	Table			Plate	Towel

- Introduce learners to the science walk they are about to start.
- Make sure to be very clear about the behaviour you expect fromthe learners during the science trail: learners should discuss while they work there way around the trail. Shouting and yelling will unnecessary disturb other classes.
- Indicate to learners the maximum time allowed for the trail, i.e. 30 minutes.



Materials every group needs for the following activity

- Worksheet 1

Activity 1

Science Trail: Materials and their uses.

- Divide learners in groups of two.
- Hand out worksheet 1 (see next page) and explain how learners should use it:
  Of all the labelled objects outside learners should describe:
  1 where it is used for;
  2 what material is it made of;
  3 what property of the material is important in this case.
- Illustrate the idea by giving an example:
  The principal's car in the school grounds:
  1 Where is it used for? *[to carry people];*
  2 What material is it made of? *[steel, mainly];*
  3 What property of the material is important in this case? *[steel is strong, does not bend easily].*

- This activity is well suited for as a practical assessment. Especially the first two column (object number/object name as well as where the object is used for) refer to observation skills of the learners. After learners have handed in their worksheets at the end of the lesson, you can marked it. One mark for every correct answer

30

Worksheet 1

- In the school grounds you will find objects labelled from 1 to 15. In **groups of two** you will go around the school grounds and answer the following questions for every object.
- For every object we would like you to find out about:
  1 where the object is used for;
  2 what material the object is used for;
  3 what property or properties of the material is important in this case?

10

object nr and name	use of object	material the object is made of	properties of material on which the use is based
1. a car	to carry people and goods	steel, mainly	steel is strong, does not bend easily
2			
3			
4			
5			
etc			

Write the names of the learners in your group on this paper and hand it in.

Finish of lesson

- Learners should move return to classand hand in their paper. While learners were busy outside you have had the change to write the home-work on the board.

Homework

- Learners hand in their papers.
- Study pages 17 - 20 of Grade 10 textbook.
- Ask learners to bring to class for next lesson:
  small pieces of wood, concrete, glass, paper, plastic, brick, cloth, pottery and metal. These will be used in next lesson's activity.

Activity Evaluation

Name of Activity:

1. Please describe your general impressions on this activity:

2. What did you like and dislike about this activity, and why?

3. How will you adapt this to your own school?

4. What things would you like to have taken out of this chapter?

5. What things would you like to have added to this chapter

6. How will you organize the timing of this lesson in your classroom?

7. What do you think about doing this activity outside? What problems do you see?

8. Do you anticipate any particular safety concerns in this activity? If so, what?

9. Will you be able to get all the materials for this activity?

   a) If not, what will you do?

   b) What specific materials will be difficult to obtain and why?

10. Do you have any comments or suggestions on this activity?

Overview and sample lesson of teacher support materials for the topic of *Materials* (version 3.1)

The first three lessons of this module concentrate on the **uses** of materials, the **properties** which make it suitable for particular uses and how these different properties can be explained by the **structure** of the material. These three very important concepts provide the focus of this chapter.

1 **Material World -** The first lesson of the topic of Materials will serve as an introduction to the various materials we use and where we find these different materials. This will take the form of a practical activity whereby learners identify a number of different materials in a vehicle. A first attempt will be made to relate the specific uses of these materials to the particular properties they have.

2 **Uses and properties of materials – Science Walk**
Learners will be involved in the Science Walk. During this activity learners will find three examples in the school ground of the each of the materials. They will answer the results in a table. Learners will also attempt the state the property which make the material suitable for that specific use.

3 **Uses and properties of materials - Posters & Discussion**
Learners make posters for each of the materials focusing on the different uses of the materials and what property makes it suitable for this use. General properties of all materials will be discussed.

4 **Properties and structure of materials - part 1**
Learners will test and classify materials they brought from home by hammering them. A start will be made on the structure of the different materials and how this affects their properties.

5 **Properties and structure of materials - part 2**
This activity is followed by a session outlining how the structure of the various materials explain the properties. At the end of this lesson the three pillars, uses, properties and structure, have been put place.

Lesson 6-9 as well as lesson 13 focus on building materials. These lessons have a high relevance to the learners' local circumstances. Most learners can tell how houses are built in their community, what kind of materials are used. Can they also tell why these materials are being used?

6 **Building materials**
This lesson focuses on the knowledge learners have about building houses and the materials used. Materials used will be different in different regions, e.g. grass is being used in Katima Mulilo, while mainly corrugated iron is used in the Keetmanshoop region. Why is this? What makes people decide whether they will use grass or corrugated iron for their roofs? Bricks are made using different materials, like mud, cement and sand in different ratios. These ratios often depend on the quality of the materials used. During this lesson some theory on the making of concrete.

7 **Brick making** - Based on what is used for making bricks in the learners' community, the learners make bricks. The learners will use mud, mud and grass, mud and cement, sand and cement with or without the addition of gravel or small stones. These bricks are allowed to dry for about a week. Learners will find out how strong the different bricks are in lesson 11.

8 **Testing of roofing materials** - Learners will investigate the insulating properties of the different roofing materials, concentrating mainly on the difference between grass and corrugated iron. Reporting of the results of the investigations will be done in the lesson 7.

9 **Roofing materials**, reporting on results and theory - Learners will report on the results of the investigation carried out in the previous lessons. A summary and an outline of some of the theoretical aspects round this lesson off.

10 **Fibres and their structure** - In this lesson learners will have a closer look at fabrics and their fibres. The use of handlenses and (preferably) a microscope will give learners the opportunity to see and draw fibre structures as well as different weaves and knits of fabrics.

11 **Fibres and fabrics** - practical activities - Groups of learners will concentrate on properties of various fabrics, such as insulating properties, ability to absorb moisture and elasticity. Results of the investigation will be presented in the next lesson.

12 **Fibres and fabrics - Reporting and discussion** Groups of learners present the results of the investigations. They will do this in the form of a poster. This lesson will be wrapped up with a look at some of the theoretical aspects of the properties of the various fabrics.

13 **Testing bricks -** Learners will test the bricks which were made in lesson 5. Two tests will be carried out. One for compressive strength (how much pressure can a brick experience before it breaks?) and the other for tensile strength (what mass can you hang from a brick before it breaks?). Conclusions will be drawn from the investigation.

14 **Soaps and detergents -** In this lesson the learners will carry out three simple experiments illustrating how soaps and detergents do their work. A short theoretical introduction to soaps and detergents will close this lesson and topic.

Lesson 1 Material World

What does this lesson look like?

- This first lesson introduces the topic of materials and sets up the framework for the rest of the lessons in this chapter. A class discussion will begin exploring the ideas and concepts which will be the focus of all the activities that follow:
  - the different *types* of materials;
  - the varying *uses* of these materials;
  - the specific *properties* of these materials;
  - the *structure* of different materials that give them certain properties.
- The teacher, together with the learners, will start to investigate which materials we use in our daily lives, how these are used, why particular materials are used for specific purposes, and how the molecular structure of these defines their useful properties. This investigation will center around all of the different materials used in a vehicle.

What are you trying to achieve in this lesson?

At the end of this lesson learners will be able to:

- *identify the main types of materials we use in our lives;*
- *know that we use different materials for different reasons;*
- *understand that the particular uses of a material are determined by its properties;*
- *recognize that the properties of materials are based on their structures.*

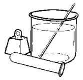
Relevant pages in Grade 10 Textbook

None, only the life experiences of yourself and your learners.

Lesson plan and timing

Activity	*Approximate time*
Start of lesson	10 minutes
Activity	20 minutes
Conclusion	5 minutes
Finishing the lesson	5 minutes
Total time	**40 minutes**

1 Preparation before the lesson



- Common samples of the different materials that will be looked at throughout this chapter (glass, rubber, hard and soft plastic, metal, wood, fabric, ceramics, concrete, and paper).
- A vehicle for the activity, such as an automobile or cart. Make sure that this vehicle is close to your classroom. Put together your own list of all the different materials that make the vehicle, and where they can be found.

[In most automobiles you can find glass, metal, ceramics (the spark plugs), rubber (the hoses), hard plastic (the battery case), soft plastic (the dash, steering wheel, etc.,.), fabric (the seats covers and carpet), and paper (labels).]

- One poster for each of the guiding questions for the Materials chapter, with the keywords (material, use, properties, and structure) highlighted:

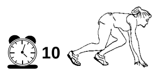
- What are the different **properties** of different **materials**?
- What **properties** make a particular **material** suitable for a specific **use**?
- How does the **structure** of a particular **material** give it certain **properties**?

These will be hung up around the classroom during the lesson, so have some Prestick or tape also ready.

- Divide the learners into groups of two or three.

1 Execution of the lesson

Start of the lesson



- Make sure that your material samples are spread out on your desk or table top before class begins, so that learners can see them as they come in the classroom.
- Show learners the samples of each type of material (glass, ceramics, metals, rubber, hard and soft plastics, wood, fabrics, paper, and concrete), and ask two questions for each material:
  1 What do we use it for?
  2 Why do we use it for that purpose?
  [Eg. Show the class a piece of glass. Ask what do we use glass for? Why do we use glass for that?]
- Try to get the learners to describe and explain two to three common uses of each material.
  [Eg. We use glass for beer bottles, because it is strong, transparent, and it is a good insulator. We use glass for windows, because it's transparent, strong, and easy to clean.]
- Write these down on the board as they are given.
- Now outline the framework of the Materials chapter for the learners on the board:

Materials

1. Use
2. Properties
3. Structure

- Explain that these three aspects of materials will be the focus throughout the lessons and all of the activities, for each type of material: how materials are used, why they are used for those purposes, and how their structures (how their atoms and molecules are bonded together, how their particles are arranged, what their composition is, or their textures) determine the properties for which they are used.

- Prepare the learners for the following activity. Instruct them to get with their partners, and each have a notebook and pen ready.

Materials required for the following activity:
A vehicle (a car or, if not available, donkey cart)

Activity 1

Exploring the vehicle: a close look at its material parts.

1 Ask the groups to each make a quick list of the materials that can be found on and in a vehicle.

2 Now write down ideas from each group on the board to help guide them on their exploration. *[Make sure you have your own list of all the materials that make up the vehicle.]*

3 Give them the following instructions:
- Write "Materials that make a vehicle" on the top of a page.
- Each group needs to find at least two uses of **each** material on or in the automobile.
- Each use is to be written down in their notebooks with the specific reasons that the material is used for that particular object or function.
- You have 10 minutes to do this.

4 Take the groups outside to the vehicle. Open up all the doors, the boot, and the bonnet so that the learners can fully explore all the possible uses of the materials that are part of the vehicle.

5 Allow the groups to investigate all the parts of the vehicle on their own, but interact with all the groups throughout the activity to keep them on task and to check their progress.

6 After 20 minutes bring them back to the classroom.

7 Lead a class discussion in which each group contributes some of its findings and ideas to a list that you write on the board for each type of material found in or on a vehicle:

E.g.

material	*use*	*properties*
glass	windows	hard, strong, transparent, waterproof
rubber	radiator hose	flexible, strong, insulator
.	.	.
.	.	.
.	.	.

20 One or two examples for each material will be fine for this exercise.

Conclusions

5
1 Review with the learners that what a material is used for is related to its particular properties. Again, refer to some of the examples they discovered during the activity.
2 Ask the learners to think about how these same properties might be

determined by the structure of the specific material (which will be looked at in Lesson 4 and 5).

3 Put up the three posters:
- What are the different **properties** of different **materials**?
- What **properties** make a particular **material** suitable for a specific **use**?
- How does the **structure** of a particular **material** give it certain **properties**?

4 Instruct the class to write these down in their notebooks. Explain that these questions will guide the rest of the investigations into the different types of materials we use in our daily lives.

Finish of lesson

5
- Reorganise the classroom and assign homework.

Homework

- Instruct the learners to find **one** example of each type of material (all ten) in or around their homes. For each of these ask them to write down the material and what its being used for in their homes on a piece of paper. This will be collected the next lesson.

Check out that car! Many different materials can be found in a vehicle

Curriculum Profile

Introduction to Lesson

A.Basic teaching skills and classroom management	yes	no	n/a	
1 Teacher appears organised and ready to start	❒	❒	❒	....
2 Teacher checks homework	❒	❒	❒	....
3 Teacher asks/answers homework questions	❒	❒	❒	....
4 Teacher discusses and reviews homework (where applicable)	❒	❒	❒	....
5 Teacher introduces the lesson (and series, if applicable)	❒	❒	❒	....
6 Teacher relates activities to previous/future lessons	❒	❒	❒	....
7 Teacher illustrates lesson topic using a demonstration	❒	❒	❒	....
8 Teacher introduces/explains key concepts	❒	❒	❒	....
9 Teacher makes use of classroom aids (blackboard etc.)	❒	❒	❒	....
10 Teacher makes reference to textbook (where applicable)	❒	❒	❒	....
11.Teacher attempts to include inattentive learners	❒	❒	❒	....
12.Teacher poses questions and waits for learners' answers	❒	❒	❒	....
13.Teacher summarises introduction with preliminary conclusion	❒	❒	❒	....

B.Learner-centred orientation	yes	no	n/a	
1. Teacher asks guided questions to introduce lesson/activity	❒	❒	❒	....
2. Teacher illustrates lesson topic by involving learners	❒	❒	❒	....
3. Teacher asks learners for their own ideas (e.g. re: activity)	❒	❒	❒	....
4. Teacher responds to learner ideas/questions	❒	❒	❒	....
5. Teacher uses learners' ideas to illustrate lesson/activity	❒	❒	❒	....
6. T. establishes the relevance of activity to learners' daily lives	❒	❒	❒	....
7. Teacher encourages learners to ask questions	❒	❒	❒	....
8. Teacher attempts to guide learners to conclusions/ideas	❒	❒	❒	....

C. Subject Matter	yes	no	n/a	
1. Teacher relays accurate information to learners	❒	❒	❒	....
2. Teacher relays complete information to learners	❒	❒	❒	....

Time allocated:______________ Actual time:______________

Body of Lesson

Lesson body start time: ....

A. Basic teaching skills and classroom management	yes	no	n/a	
1. Teacher introduces the activity	❒	❒	❒	....
2. Teacher has essential materials ready and organised	❒	❒	❒	....
3. T. makes sure that materials are easily accessible to learners	❒	❒	❒	....
4. Teacher explains how to use materials/equipment	❒	❒	❒	....
5. Teacher moves around classroom	❒	❒	❒	....
6. Teacher stimulates less motivated groups	❒	❒	❒	....
7. Teacher responds positively to learner's questions/answers	❒	❒	❒	....
8. T. maintains a positive learning environment during activity	❒	❒	❒	....
9. Teacher effectively handles discipline problems	❒	❒	❒	....
10. Teacher effectively handles timing difficulties	❒	❒	❒	....
11. Teacher successfully improvises because time runs short	❒	❒	❒	....
12. Teacher provides worksheets (where applicable)	❒	❒	❒	....
13. Teacher's preparedness contributes to a "smooth" lesson	❒	❒	❒	....

B. Learner-centred orientation	yes	no	n/a	
1. Teacher groups learners for activity	❒	❒	❒	....
2. T. assigns appropriate number of learners to each group	❒	❒	❒	....
3. Teacher considers the member composition of each group	❒	❒	❒	....
4. Teacher assigns various group roles to members	❒	❒	❒	....
5. Teacher gives practical instructions to the groups	❒	❒	❒	....
6. Teacher stresses safety instructions (where applicable)	❒	❒	❒	....
7. Teacher tells students what the objectives are for the activity	❒	❒	❒	....
8. Teacher allows students "room to choose" their own approach	❒	❒	❒	....
9. Teacher observes how learners choose to approach activity	❒	❒	❒	....
10.Teacher makes sure learners execute activity and use materials/equipment correctly	❒	❒	❒	....
11. Teacher interacts with students during activities	❒	❒	❒	....

	yes	no	n/a	
12. Teacher interacts equally with all groups	❐	❐	❐	....
13. Teacher assists learners when necessary (but not immediately)	❐	❐	❐	....
14. Teacher guides learners (via questioning, referral, etc.)	❐	❐	❐	....
15. Teacher allows learners to draw own conclusions in groups	❐	❐	❐	....
16. Teacher encourages learners to ask questions	❐	❐	❐	....
17. Teacher gives answers to learners too quickly	❐	❐	❐	....
18. Teacher tries to understand learner problems/questions	❐	❐	❐	....
19. Teacher readily grasps/handles learner problems/questions	❐	❐	❐	....
20. Teacher discusses results/problems with a particular group	❐	❐	❐	....

C. Subject Matter

	yes	no	n/a	
1. T. gives clear, correct, and complete information to the groups	❐	❐	❐	....
2. Teacher relates information to other past/future topics/activities	❐	❐	❐	....

Lesson body end time: ....

Allocated time:_____________ Actual time:_____________

Conclusion of Lesson

A. Basic teaching skills	yes	no	n/a	
1. Conclusions are drawn from activity	❐	❐	❐	....
2. Teacher summarises the findings of the activity	❐	❐	❐	....
3. Teacher discusses the methods used: correct and incorrect	❐	❐	❐	....
4. Teacher asks learners questions and waits for a response	❐	❐	❐	....
5. Teacher spends time discussing activity afterward	❐	❐	❐	....
6. Teacher gives specific homework	❐	❐	❐	....
7. Homework is given before the end of the lesson	❐	❐	❐	....
8. Teacher insures students' awareness of assignment (eg:board)	❐	❐	❐	....
9. Teacher explains homework clearly	❐	❐	❐	....
10. Teacher explains significance of the homework (re: activity)	❐	❐	❐	....
11. Teacher/learners clean-up classroom	❐	❐	❐	....

B. Learner-centred orientation	yes	no	n/a	
1. Teacher asks each group to report their results to the class	❐	❐	❐	....
2. Teacher asks groups for specific information/results	❐	❐	❐	....
3. Teacher draws conclusions with the learners from the activity	❐	❐	❐	....
4. Teacher responds to questions/answers from learners	❐	❐	❐	....
5. Teacher asks learners to report on their methods	❐	❐	❐	....
6. Teacher guides learners to understand discrepancies in their results	❐	❐	❐	....

C. Subject Content	yes	no	n/a	
1. T. effectively and correctly addresses discrepancies in group results	❐	❐	❐	....
2. Teacher provides theory for observed group results				
3. Teacher refers back to introductory theory	❐	❐	❐	....
4. T. provides general theoretical conclusions from activity	❐	❐	❐	....

Allocated time:_____________ Actual time:____________

Overall impressions

A. Basic teaching skills

	yes	no	n/a	
1. Teacher listens to learners answers	❐	❐	❐	....
2. Teacher responds positively to learner inquiry	❐	❐	❐	....
3. Teacher asks "thought-provoking" questions to learners	❐	❐	❐	....
4. Teacher uses teaching aids for further clarification	❐	❐	❐	....
5. Teacher's expectations of learners' behaviour are clear	❐	❐	❐	....
6. Where applicable, teacher has worksheets for students	❐	❐	❐	....
7. Teacher is well organised and prepared for lesson/activity	❐	❐	❐	....
8. Teacher uses available time efficiently	❐	❐	❐	....
9. T. appears to understand the objectives and activities of lesson	❐	❐	❐	....
10. Teacher makes use of classroom aids (blackboard etc.)	❐	❐	❐	....
11. Classroom is decorated with relevant visual aids	❐	❐	❐	....
13. Teacher improvises (eg. time/unavailability of materials)	❐	❐	❐	....
14. Teacher improvisations are effective	❐	❐	❐	....

15. Teacher uses methods different from those in teacher guide ❒ ❒ ❒ ....
16. Improvised methods are effective ❒ ❒ ❒ ....
17. The actualisation of the lesson understandable/orderly ❒ ❒ ❒ ....

B. Learner-centred orientation

1. Teacher acknowledges learners' ideas (eg. questions/answers) ❒ ❒ ❒ ....
2. Teacher uses/discusses learners' ideas ❒ ❒ ❒ ....
3. Teacher summarises learners' long answers ❒ ❒ ❒ ....
4. Is the classroom atmosphere conducive to learning? ❒ ❒ ❒ ....
5. Classroom atmosphere seems to encourage learners to ask/answer questions ❒ ❒ ❒ ....
4. Are materials produced by the learners displayed around the classroom? ❒ ❒ ❒ ....

C. Subject matter

1. Learners meet overall lesson objectives ❒ ❒ ❒ ....
2. Teacher appears confident in lesson content ❒ ❒ ❒ ....
3. Teacher appears competent in lesson content ❒ ❒ ❒ ....
4. Teacher notices and responds to incorrect learner answers ❒ ❒ ❒ ....
5. Teacher seems to have a firm understanding of subject area ❒ ❒ ❒ ....

Total length of lesson (minutes): ....

General observations:
Number of learners in class:....................
Number of small groups:.........................
Average number of members in a group:.........................
Summary of the learners' response to the lesson:
What is the teacher's questioning style?
How does the teacher respond to questions?
What is the classroom layout like?
Description of the classroom environment

Lesson 1

Lesson topic: ____________________
Lesson date: ____________________
Lesson time: ____________________
Name teacher: ____________________
Number of pupils in class: ______

1. General impression of lesson

Not useful	1	2	3	4	Very useful
Many problems	1	2	3	4	Ran smoothly
Time problems	1	2	3	4	Suggested time OK
Lesson aims not met	1	2	3	4	Lesson aims were met

2. Lesson preparation

2.1 Was the teacher guide useful during the preparation of the lesson? **Yes/No**
If yes, in what way? ____________________

If not, why? ____________________

2.2. Which activities did you carry out to prepare for this lesson and how much time did you spend on each activity?

Activity		*Time (minutes)*
Finding the equipment		______
Trying out the practical activity		______
Reading textbook and teacher guide		______
Arranging equipment for learners		______
Other, please specify	______________	______

2.3 Does the teacher guide provide enough information to understand the intention and the set-up of the lesson? **Yes/No**

2.4 Does the teacher guide give enough information about the materials required for this lesson? **Yes/No**

2.5 Did you encounter problems during the preparation of this lesson? **Yes/No**
If yes, please explain what these problems were
____
____

2.6 Please tick one or more of the following if you agree with them:
❑ the preparation was very time-consuming
❑ the preparation was very complicated
❑ the teacher guide helped me a lot with the preparation

2.7 Do you feel the teacher guide needs changes or additions to help with a more efficient lesson preparation? **Yes/No**
If so, which changes?
____
____

2.8 Did you improve or adapt the lesson? **Yes/No**
If yes, please list the additional ones needed:
____

3. Materials required

3.1 Were all items required for this lesson also mentioned in the teacher guide? **Yes/No**
If not, please list the ones you missed.
____
____

3.2 Were all items you required easily available? **Yes/No**
If not, please list the ones you had problems finding:
____
____

3.3 Did you find alternatives for the items you did not have? **Yes/No**
If yes, which items? ____________________

4. Activity carried out by the learners

4.1 What was your impression of the activity learners carried out during this lesson?
❑ very useful ❑ a bit useful ❑ not useful

❑ easily understood by learners ❑ difficult for learners

Any additional comments you would like to make:
____
____

4.2 Were there specific problems with this activity? **Yes/No**
If so, which ones?

____

____

4.3 How could the teacher guide have helped to overcome these problems?

____

____

4.4 What was **your role** during the activity in this lesson? Tick one or more of the options below.

- ❑ active participant
- ❑ assessor of learners
- ❑ explainer
- ❑ guide of learners with difficulties
- ❑ an interested spectator
- ❑ other, please specify ______

____

Why did you assume this role during the activity? ______

____

5. Timing

5.1 Please compare the time you spent on the various lesson components to the times indicated in the teacher guide. If you skipped one of the components below enter '*0 minutes*' in the time column. If you changed a component, please indicated that under '*Other components*' together with the time you spent on it.

Activity	*Time (minutes)*
Start of the lesson	______
Activity	______
Conclusions	______
Finish of the lesson/Homework	______
Other components ______	

6. Lesson objectives

6.1 Do you feel the aims of this lesson were achieved? **Yes/No**
If not, please indicated which aims were not met and why not.

____

6.2 How many percent of the lesson did you cover? ______

7. Learners' participation

7.1 How was the participation of the learners during this lesson?

Passive	1	2	3	4	Active
Dependent	1	2	3	4	Independent
Uninterested	1	2	3	4	Interested

Any additional comments: ______________________________

____

____

7.2 What changes in the set-up of this lesson could increase the participation and motivation of the learners, if necessary?

____

____

7.3 What changes in the set-up of this lesson could increase learning outcomes of this lesson?

____

____

8. Homework

8.1 Did you check homework at the beginning of the lesson? **Yes/No**
How did you do this? Tick the appropriate box

- ❑ Asked a few learners questions
- ❑ Gave a test
- ❑ Not applicable
- ❑ Checked learners' books during class
- ❑ Did not check homework

8.2 Were you satisfied with the way learners carried out their homework activities? **Yes/No**

8.3 Did you give homework at the end of this lesson? **Yes/No**
If so, list what the homework was, e.g. ' *Questions 1and 2 of chapter 2 of the grade 10 textbook'.*

____

____

Semi structured teacher interview

Personal data
Age, qualifications, teacher certificate, experience, present subjects they teach in which grades, position in school, others.

Expectations
Beforehand, were you worried about teaching the 'Materials' topic?
- discipline problerns
- reactions of learners
- other problerns

While you were conducting the lessons, were they as you expected?
Afterwards, have the lessons lived up your expectations?

Appreciation of lessons
- How did you like the 'Materials' topic in general?
- Which lesson(s) did you like the best? Why?
- Which lesson(s) did you lilce the least? Why?

Learner-centred teaching
- The teacher guide is supposed to support learner centred teaching. Has the teacher guide succeeded in doing that? Explain how, give exernples!
- Is the school/your principal/cornrnunity supportive to the learner-centred teaching approach? Give examples where this is (not) the case.
- Does the teacher guide provide enough information and support on the new learner-centred teaching approach?
- Does the teacher guide provide enough information on the guiding of group activities?
- Did you succeed to be learner-centred in you teaching during the 'Materials' topic?
- Did you manage to actively involve the learners during the lessons?

Content of the lessons
- Does the teacher guide provide enough subject knowledge support and information?
- Did you find the content of the lessons useful and relevant to the learners' daily life experience?
- Which lessons (content) did you find (less) useful and (less) relevant (or even redundant)?
- Is the order of the lessons to your liking?
- Do you think the 'Materials' topic needs more lessons to cover it properly?
- Were the activities during the lessons suitable and useful?
- Which activities in the lessons did you find (less) useful or redundant?
- Is the level of the lessons (activities) suitable for grade 10 1earners?

Lesson execution
- Were there any problems with any of the activities?
- Did the activities help to meet the lesson aims?
- Which one of the lessons was the most problematic to execute? What was the reason for this? Which problems did you encounter?
- Were all materials and supplies required for the activities available at school or easily available elsewhere?
- Were you able to cover the individual lessons in one 35-40 minutes period?

Lesson effects
- What did you learn from the 'Materials' lessons?
- Were the lessons different from your normal lessons? If yes, in what way?
- Were the aims of the lesson series met?

Your opinion of the teacher guide
- Does the teacher guide have a useful format (to carry around/ to use in class)?
- What is your opinion about:
    - use of language
    - writing style
    - lay-out illustrations
    - use of icons?
- Would you have been able to teach the topic without the teacher guide?
- Is there a need to make changes (additions, deletions) for the final version of the teacher guide?

Lesson preparation
- Did it take more (or less) time to prepare for these lessons than for your normal lessons?
- Was the preparation time for the lessons acceptable?
- Can preparation time be shortened (if yes, how)?
- If you encounter problems with the preparation of a lessons, who can you consult?

If....?
- How would the lessons have been different if you had to do without the teacher guide?
- How would the lessons have been different if we had not been in the back of the class?
- What has been the difference between these lessons and your normal Physical Science lessons?
- Will you be using this teacher guide next year for your grade 10 1earners?

Book
- To what extent did you and your learners use the grade 10 textbook for the 'Materials' lessons
- Which parts of the theory did you use?
- Did you use the questions at the end of the chapter?
- How do the learners use the book? (as a resource, guide for instructions, etc.)

Appendix 6.11 - Student questionnaire

1. Was there anything in particular that you liked or disliked about the lessons?
   I liked:

   I did not like:

2 Which one of the lessons did you like best?

   Give a reason why?

3 Which one of the lessons did you like the least?

   Give a reason why?

4 Were the lessons different from the normal physical science lesson?

   Yes/No

   If you answered yes, try to explain what the differences were.

5 Describe what you learned from the lessons?

6 Describe how what you learned, can help you in your daily life?

7 How old are you?

8 Are you a boy or a girl?

Appendix 6.12 - Student interview plan

1. What are your names?
2. Do you like Physical Science and do you like the topic of ‘Materials? Why?
3. Do you find physical science difficult?
4. Did you like the lessons on the topic of ‘Materials’?
5. Which one did you like best and why?
6. Which one did you like least and why?
7. Was there any difference between the normal physical science lessons and the lessons on ‘Materials’?
8. Can you give some differences between the normal lessons and the ‘Materials’ lessons?
9. Which lessons did you like better, the normal lessons or the ‘Materials’ lessons?
10. Do you do practical work in your normal physical science lessons?
11. How many times did you do practical work before the ‘Materials’ lessons?
12. Did you understand everything what you were doing during the ‘Materials’ lessons?
13. Which lessons do you understand better: the normal lessons or the ‘Materials’ lessons?
14. Do you think the whole class will understand the ‘Materials’ lessons?
15. How many learners, do you think, will not understand the ‘Materials’ lessons?
16. Did you study the homework the teacher gave you (from the textbook)?
17. Is the ‘Materials’ chapter in the textbook clear/difficult?
18. What do you think: which lessons are more difficult: the normal physical science lessons or the ‘Materials’ lessons?
19. Did you understand the English terms your teacher used during the ‘Materials’ lessons?
20. How many learners do you think will not understand the English?
21. What have you learned from the ‘Materials’ lessons?
22. Is what you have learned useful to you? Explain!
23. How will you use what you have learned in your daily life, at home in the village?

Appendix 6.13 Katima Mulilo student test

Grade 10 Aees

Question 1

In the following list you see materials you used during the last few weeks.

wood, fabric, rubber, glass, paper, concrete, hard plastic, soft plastic, grass, ceramics.

a. Some of these materials shatter easily while others do not shatter.
From the list of materials choose the ones that shatter and the ones that do not shatter and put them in the correct columns below:

materials that shatter	materials that do not shatter
Concrete ✓	Wood ✓
Hard plastic ✓	Fabric ✓
Glass ✓	rubber ✓
~~Ge~~	Soft Plastic ✓
	Paper ✓
	Grass ✓
	Ceramic ✗

b. (i) If you wanted to make a windscreen for a car, which one of the materials listed above would you use?
Glass ✓ and

(ii) Which property makes the material particularly suitable for a windscreen?
Water proof ✗

c. Bottles are sc … two advantages o… …d for making bottles.

A	…ic bottle
Water proof ✗ attractive ✗	it breaks easily it does not stay ✗ for a long time

1d. Describe the structures of the two groups of materials mentioned in **a.** above.

Structure of materials that **shatter**:
electrostic bond
Ionic bonding ✓
covalent bonding ✓

Structure of materials that **do not shatter**:
electrostic bonding ✗

Question 2

Walls of houses of often made of concrete bricks.

a. Which substances are used to make concrete?

Cement mixed with ~~water~~ sand.

b. Give a reason why you would want to use concrete bricks for building a house.

because it stays for a longtime

c. How can you increase the strength of bricks?

by comprehesive and tensil strength

d. Describe how you would test the compressive strength of bricks.

you take a table and put the ~~stone~~ bricks on it and put the stone on top of the brick and the the bucket of water on top of the stone

e. Cement is made by heating together two substances. Name them.

Stone and Sand

f. Where in Namibia do you find a cement factory?

In Otjiwarongo

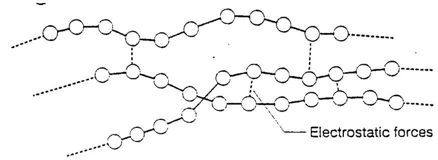
g. Sometimes materials **other than concrete** are used for walls of houses. Name two.

1. Mud 2. Plant

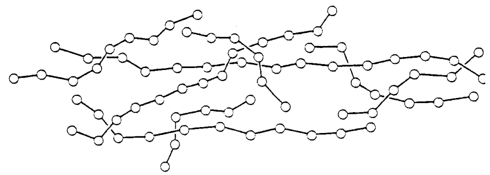
Question 3

Plastics are made of polymers. Different kinds of plastics have different properties. Below you find diagrams of three different plastics.

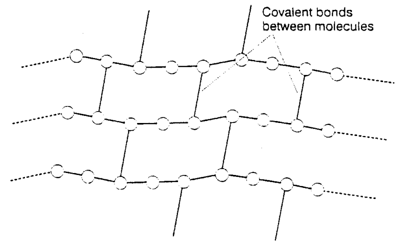
Polymer A



Polymer B



Polymer C



a. Describe the way the chains in the three polymers are arranged (e.g. all in the same direction).

Polymer A ~~Nylon~~. Polythene

Polymer B ~~Plastic~~ ~~Nylo~~ ~~Polythene~~ Nylon

Polymer C melamine.

b. Describe the way the chains in the three polymers are held together.

Polymer A ~~same direction~~ ~~week forces~~ strong forces

Polymer B ~~different direction~~ week forces

Polymer C ~~same direction~~ electrostic forces

c. Compare the strength of the three polymers and order them from the weakest to the strongest

Polymer B
Polymer A
Polymer C

d. Explain why you have chosen this order.

Because Polymer C the forces are So strong thane in Polymer B and they are in the same direction

e. Which one of the three polymers will be the **hardest**?

Explain your answer.

is Polymer C because they are in the same direction and they are covalent bond between molecules

Question 4

a. What are fibres and where do we use them for?

Fibres they are fabrics

Use of fibres in wood and clothes

b. What do you understand by the following?

(i) Natural fibres are fibres which are seen

(ii) Synthetic fibres which doesn't seen

c. Give two examples of each.

(iii) Natural fibres: Polythen and Polyester

(iii) Synthetic fibres: Nylon and melamine

Question 5

plastic, metal, rubber, concrete, ceramic, wood, paper, fabric, glass, grass

a. Choose one or more of the above materials to make the objects below.

b. For every material you choose please indicate which property makes it particularly suitable for that use.

The first one is given as an example.

(i) a cup: ceramics

property: it is hard and strong, easy to shape in any form.

(ii) a bottle Glass.

property: it breaks easily and it shatters

(iii) insulation material for electrical wires Rubber

property: is ~~sel~~ last longer

(iv) a tyre for your bicycle:

property:

(v) a blanket Fabric

property: ~~it~~ gives warm insulater.

(vi) fishing line

property:

(vii) a door for your house metal

property: it is hard and it last for a long time

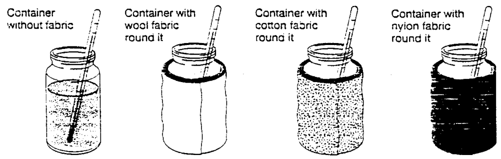
(viii) a soccer ball Hard Plastic

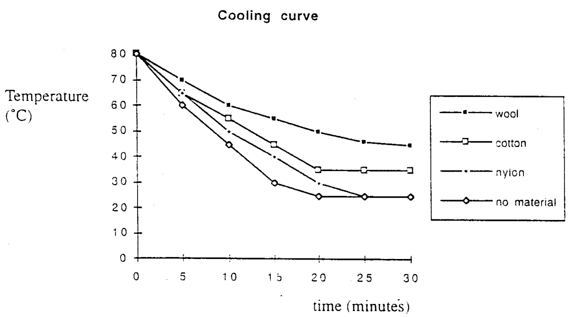
property: it is hard.

Question 6

In a grade 10 science lesson learners carried out an experiment to find out why some clothes feel warmer than others. The learners used four containers. One was wrapped with a piece of wool fabric, another with cotton, and the third with nylon. One container was without fabric. The fabrics all had the same length and width. (See diagram below). The learners poured 150 cm³ of hot water in all four containers. They immediately measured the temperature.

The learners read all four thermometers at 5 minutes intervals for 30 minutes. They plotted a graph of the results (see graph below).





Using the results of the experiment in the graph answer the following questions:

(a) What was the temperature of the hot water the learners poured into the containers?
80° C. ✓ (1)

(b) Which one of the fabrics is the best insulator?
Wool ✓ (1)

(c) Briefly explain why.
because it traps air. ✓ (2)

(d) Which one of the fabrics would you use to keep warm during winter?
wool ✓ (1)

(e) Which one of the fabrics would you use to wear on the sports field?
Nylon ✓ (1)

Question 7

Most houses in Namibia are covered with **grass** roofs or **corrugated iron** roofs.

a. Give **two** advantages of grass roofs.
1. It is easy to get ✓
2. It is cheap. ✓

b. Give **one** disadvantage of grass roofs.
It does not last for a long time ✓

c. Give **two** advantages of corrugated iron roofs.
1. water proof ✓
2. It is attractive ✓

d. Give **one** disadvantage of corrugated iron roofs. ✓
It is too expensive

In Katima Mulilo region most houses have grass roofs. However in the Keetmanshoop region most houses have corrugated iron roofs.

e. What could be the reason for this?
In Keetmanshoop region most of the people ✓
they are working and there is no grass for building houses and in Katima
Mulilo people they are not working and
there is lot of grass for building houses

Question 8

Why is it much easier to wash oil off your hands with soap or a detergent than with just water?

because in soaps or in a detergent
the is some chemical in it thats ✓
why if you wash your hands with soap you get
clean easier.

- End -

Appendix 6.14 Keetmanshoop student test

Chapter 2 Topic Test
Materials
Grade 10

Name: [illegible] Andrew

58

(6 Marks)

Read all the instructions carefully then answer all of the test questions on this paper.

I. Multiple Choice: circle the correct answer.

1. 1. Materials made of long chains of carbon molecules are called:

   a. ionic compounds
   b. metals
   c. polymers
   d. ceramics

2. Which type of structure will shatter easier?

   a. ionic
   b. covalent
   c. metallic

3. If a material is a good conductor then its BEST use would be:

   a. a tea cup
   b. a vehicle tyre
   c. a window
   d. a cooking pot

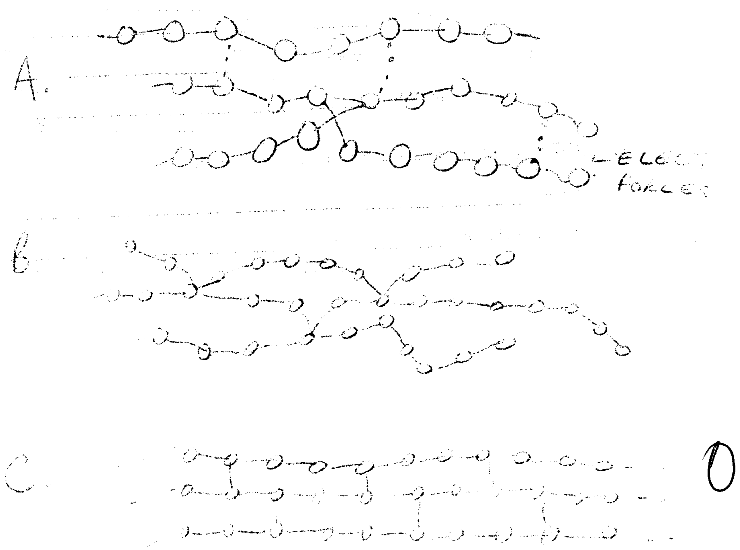
II. Short answer questions: complete each question in the space provided.

1. Plastics are made of polymers. Different kinds of plastics have different properties. Below you find diagrams of the three different plastics:

A.

B.

C.



0

2

a. Describe the way the chains in the three polymers are arranged (eg. all in the same direction).

Polymer A far from ~~its~~ one another

Polymer B circle form

Polymer C In a right angle form close to another

b. Describe the way the chains in the three polymers are held together.

Polymer A far from one another

Polymer B not too far from one another.

Polymer C Close to another

2. You are given the following materials:

soft plastic, metal, rubber, concrete, hard plastic, ceramic, wood, fabric, glass, paper

a. Choose one or more of the above materials to make the objects below.

b. For every material you choose please indicate which property makes it particularly suitable for that use.

First one is given as an example.

(i) a cup: ceramic
property: it is hard and strong, easy to shape in any form.

(ii) a bottle glass
property You can see [illegible] it Waterproof

(iii) a blanket fabric
property [illegible] Winter

(iv) a door for your house wood
property It is hard and strong

Appendix 6.15 Completed curriculum profiles of teachers T1-T6

Table 1 - Lessons of teacher 1

Teacher 1		L10	L10a	L11	L14	L14a	Total (%)
Start of lesson	Basic teaching skills	5/7	-	4/12	9/13	5/7	61
	Learner-centred teaching	4/6	-	-	5/7	6/7	75
	Subject matter	2/2	-	2/2	2/2	2/2	100
Body of lesson	Basic teaching skills	8/10	8/9	6/8	7/11	-	75
	Learner-centred teaching	12/18	7/12	6/14	14/17	-	63
	Subject matter	1/2	1/1	1/2	1/2	-	63
Conclusion of lesson	Basic teaching skills	4/11	7/10	-	-	8/10	62
	Learner-centred teaching	1/6	3/3	-	-	6/6	72
	Subject matter	0/4	4/4	-	-	4/4	67
Overall impression	Basic teaching skills	9/15	9/12	7/13	-	13/13	72
	Learner-centred teaching	3/5	4/4	1/2	-	5/6	73
	Subject matter	4/5	5/5	4/4	-	5/5	95

Legend:
L10a Lessons with suffix 'a' are continuations of the previous lessons.
4/11 four of the 11 element on the curriculum profile are scored with 'yes'. Some other elements do not apply.
\- lesson is spread over more lessons. Conclusions from the activity are drawn in the next lesson. Or activity took place during the lesson before.

Table 2 - Lessons of teacher 2

Teacher 2		L8	L8a	L10	L11	L12	L13	Total (%)
Start of lesson	Basic teaching skills	8/12	5/5	7/12	8/10	-	5/7	75
	Learner-centred teaching	5/6	2/4	7/8	-	-	1/2	68
	Subject matter	2/2	2/2	2/2	2/2	-	2/2	100
Body of lesson	Basic teaching skills	9/10	8/9	9/10	8/8	5/5	8/9	93
	Learner-centred teaching	14/16	9/17	15/19	12/20	10/11	7/11	72
	Subject matter	2/2	1/2	2/2	1/2	2/2	1/2	75
Conclusion of lesson	Basic teaching skills	-	8/11	9/10	-	4/6	7/11	73
	Learner-centred teaching	-	3/4	5/5	-	4/6	2/4	73
	Subject matter	-	0/3	4/4	-	1/4	0/3	31
Overall impression	Basic teaching skills	13/15	15/16	14/16	8/12	11/12	12/15	84
	Learner-centred teaching	4/6	5/5	4/5	5/6	6/6	4/5	85
	Subject matter	4/4	5/5	5/5	5/5	5/5	4/4	100

Legend: as in table 1

Table 3 - Lessons of teacher 3

Teacher 3		L1	L2	L3	L4	L5	Total (%)
Start of lesson	Basic teaching skills	7/19	9/12	8/13	11/12	4/12	60
	Learner-centred teaching	7/7	2/5	7/8	7/8	8/8	83
	Subject matter	2/2	2/2	2/2	2/2	0/2	80
Body of lesson	Basic teaching skills	6/7	5/5	8/8	9/9	4/7	89
	Learner-centred teaching	12/17	12/18	14/18	15/17	5/7	75
	Subject matter	1/2	-	2/2	2/2	1/2	75
Conclusion of lesson	Basic teaching skills	10/10	7/10	7/9	7/10	4/7	75
	Learner-centred teaching	3/4	4/4	2/4	4/4	1/1	85
	Subject matter	2/2	-	1/3	2/2	0/2	58
Overall impression	Basic teaching skills	10/13	11/12	12/13	15/16	7/12	83
	Learner-centred teaching	4/4	6/6	5/6	6/6	6/6	97
	Subject matter	5/5	5/5	5/5	5/5	0/4	80

Legend: as in table 1

Table 4 - Lessons of teacher 4

Teacher 4		L1	L2	L3	L4	L5	L6;L7; L8	Total (%)
Start of lesson	Basic teaching skills	8/10	8/9	7/8	10/10	12/12	8/13	86
	Learner-centred teaching	8/8	8/8	6/7	8/8	8/8	8/8	98
	Subject matter	2/2	2/2	2/2	2/2	2/2	2/2	100
Body of lesson	Basic teaching skills	10/10	11/13	10/10	11/12	9/10	10/10	94
	Learner-centred teaching	17/19	18/19	17/19	18/18	15/15	15/15	96
	Subject matter	1/2	2/2	2/2	2/2	2/2	1/2	83
Conclusion of lesson	Basic teaching skills	10/10	5/8	9/10	8/9	8/10	8/9	85
	Learner-centred teaching	4/4	3/4	4/4	6/6	5/5	1/2	88
	Subject matter	3/3	1/2	2/3	4/4	4/4	1/1	86
Overall impression	Basic teaching skills	14/15	12/14	13/13	14/15	13/13	13/15	93
	Learner-centred teaching	5/5	6/6	6/6	6/6	6/6	6/6	100
	Subject matter	5/5	5/5	5/5	5/5	5/5	5/5	100

Legend: as in table 1

Table 5 - Lessons of teacher 5

Teacher 5		L1	L2	L3	L3a	L4	L5	Total (%)
Start of lesson	Basic teaching skills	7/10	5/13	4/12	5/8	7/12	7/8	58
	Learner-centred teaching	8/8	1/8	0/6	8/8	6/8	6/8	60
	Subject matter	1/2	1/2	0/0	2/2	1/2	1/2	60
Body of lesson	Basic teaching skills	11/11	9/11	6/11	7/7	10/13	6/6	86
	Learner-centred teaching	14/16	18/19	17/19	-	18/19	-	92
	Subject matter	0/1	2/2	1/2	2/2	1/2	1/2	58
Conclusion of lesson	Basic teaching skills	6/9	6/11	3/7	8/9	4/6	5/7	65
	Learner-centred teaching	4/4	3/6	3/4	1/2	4/4	0/1	63
	Subject matter	0/2	1/2	1/3	2/3	3/3	2/2	58
Overall impression	Basic teaching skills	12/13	11/14	11/16	13/14	10/12	11/14	82
	Learner-centred teaching	5/6	5/6	4/6	5/6	5/6	5/6	81
	Subject matter	4/4	5/5	3/5	5/5	4/5	3/4	86

Legend: as in table 1

Table 6 - Lessons of teacher 6

Teacher 6		L1;L2 (*)	L3	L4	Total(%)
Start of lesson	Basic teaching skills	8/8	9/9	6/9	89
	Learner-centred teaching	8/8	8/8	4/8	83
	Subject matter	2/2	2/2	2/2	100
Body of lesson	Basic teaching skills	12/12	11/11	11/11	100
	Learner-centred teaching	18/19	18/19	18/20	93
	Subject matter	2/2	2/2	2/2	100
Conclusion of lesson	Basic teaching skills	-	5/6	6/7	85
	Learner-centred teaching	-	4/6	5/6	75
	Subject matter	-	3/4	4/4	88
Overall impression	Basic teaching skills	14/16	13/14	13/14	91
	Learner-centred teaching	5/6	5/6	6/6	89
	Subject matter	5/5	5/5	5/5	100

Legend: as in table 1
(*) Lesson 1 and 2 are combined into one.

Lesson 2

Uses and Properties of Materials - Science Walk

What does this lesson look like?

In this lesson learners will observe, in their own environment, what specific materials are used for. This lesson takes the form of a Science Walk with the learners *observing* different materials in a variety of different locations around the school. Learners will be asked to describe how and what for the materials are used, to state why this material used in this specific case and how this relates to the properties of the material.

What are you trying to achieve in this lesson?

At the end of this lesson learners will be able to:

- *classify materials as wood, metals, glass, ceramics, hard and soft plastics , rubber, fabrics, paper, wood and concrete.*
- *identify examples of these materials in the local environment.*
- *describe and explain how these materials are used and what properties they are being used for.*

To achieve these learners will be involved in the Science Walk. They will observe the use of different materials around the school. Discussions in the groups and plenary discussion of the results of the Science Walk should provide learners with an understanding that materials are used because of specific properties they have; e.g. a windscreen of a car because you can see through it, but also because it breaks the wind (and protects from rain).

Relevant pages in Grade 10 Textbook

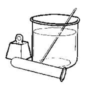
Pages 16 and 17 (assignment 2A).

Lesson plan and timing

Activity	*Approximate time*
Start of lesson	5 minutes
Science Walk	25 minutes
Conclusion	5 minutes
Finish of lesson/Homework	5 minutes
Total Time	**40 minutes**

2 Preparation before the lesson

- Divide learners in groups of not more than three.



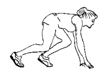
- Prepare a **worksheet** for every group. This worksheet should have questions about the objects learners will investigate around the school. The materials of which the objects are made should fall in the following categories: Glass, wood, plastic, metal, ceramics (pottery), fabrics,

paper, concrete, rubber, hard and soft plastics.
- A sample worksheet is **included** at the end of this lesson.

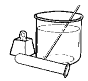
2 Execution of the lesson

Start of lesson

5



- Collect the homework assigned at the end of lesson 1. This mark can be part of the learners CASS mark.
- In our daily lives we use a great many objects. These objects are made of a variety of materials. The properties of a particular material make it very useful for certain things.
- Introduce learners to the science walk they are about to start.
- Make sure to be very clear about the behaviour you expect from the learners during the Science Walk: learners should discuss while they quickly work on finding examples of materials around the school. Shouting and yelling will unnecessary disturb other classes.



- Indicate to learners the maximum time allowed for the Walk, i.e. 25 minutes.

Materials every group needs for the following activity

- Science Walk Worksheet (included at the end of this lesson)

Activity 1

25

Science Walk: Materials and Uses

- Divide learners in groups of three.
- Hand out the Science Walk worksheet and explain how learners should use it. For each type of material learners should describe:
  1 example of the material in use;
  2 where it is used for;
  3 what property of the material is important for the particular use.
- Illustrate the idea by giving an example:
  Concrete:
  1 example of the material in use - *concrete brick*;
  2 where it is used for? - *walls to support roof, protection from weather;*
  3 what property of the material is important for the particular use? - *strong, avaiable, cheap, easy to make.*
- Re-state the rules of being outside just before they leave the room.
- Make sure that students try to avoid to cut themselves when outside.
- Interact with the groups during this activity, but let them do the observations. Ask guiding questions rather than answering the questions for the learners.
- After 25 minutes bring the groups back into the classroom. If students get restless, bring them in earlier, as this may indicate that they have finish the task.

Conclusions

5

- Briefly discuss some of the group findings with the class as a whole.
  Focus on:
  1. Examples of materials in use
  2. What were materials used for?

 5

3. What specific properties were these materials used for?
4. Can students already draw the conclusion that a material is used because of a specific property. It might therefore be good for one use, but not for another. Give an example (such as the use of wood for a stool) to finish the lesson.

Finish of lesson

- Write homework on the board and make sure the classroom is back in order.

Homework

- Instruct the learners to hold onto the worksheet and, if necessary, complete the worksheet for the next lesson.
- Study pages 16-17 of Grade 10 textbook.

The school's rubbish dump provides a wealth of different materials. Be careful not to cut yourself.

Worksheet

Science Walk

- In the school grounds you will find different materials being used in many different ways. In groups of three you will go around the school grounds and complete the following table for every type of material.
- For every material find:
  1 an object made of this material.
  2 what the material is being used for?
  3 what property or properties of the material is (are) important for that use?
- Find two examples of each material in use.

Material	object	use	properties
			What makes this material so useful for the object it is used for? Because it is:
glass	window pane	in class window	waterproof; transparant
glass			
ceramics			
ceramics			
metal			
metal			
rubber	tyre	on a wheel	flexible, stretches, strong
rubber			
plastic			
plastic			
wood			
wood			
fabric			
paper			
paper			
concrete			
concrete			