Partnerships for relevant science and technology education

Report of a sub-regional workshop on private sector partnerships in science and technology education in southern Africa

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for UNESCO

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Preface

The workshop 'Partnerships to Enhance Science and Technology Education in Southern Africa', held in Windhoek, Namibia, 28–30 July 2003, was part of a series of regional workshops on science and technology education (STE), organized by UNESCO in order to identify regional trends and priorities, facilitate regional partnerships and networking in STE as well as to develop proposals on UNESCO's action in the region.

This document is based on the discussions and recommendations of the workshop, and goes on to analyse the state of STE in the region and of regional initiatives with regard to private–public partnerships (PPP) in STE.

One of UNESCO's principal functions is to facilitate exchange on expertise and good practices in education, and to provide assistance to governments to adapt their education polices to a fast changing world. The workshop gathered representatives from the public, as well as from the private sector, from eight countries in the SADC region to discuss and explore how PPP and regional networking can improve the quality and quantity of STE at secondary level in order to respond to needs of the countries' growing economies. (Read more on the workshop details in Appendix A.)

The event was organized with the profound conviction that a continuous and vivid dialogue between education providers and potential employers is imperative in order to adapt STE contents to the demands of the world of work – as well as to match demand and supply for science education at policy level. Such a dialogue should further remind the employing sector of its responsibility and its direct interest in investing and supporting an education that responds to its needs of skilled labour in the field of science and technology (S&T).

All stakeholders at the workshop agreed that investment in S&T education is vital to economic and social development and it needs the resources and co-ordination of the two sectors in order to achieve an improvement of STE in the region.

The private sector pleaded for a change from a supply driven education mode to a more demand-driven one, the need for clear partnership frameworks and priorities, the necessity to be involved in curriculum development and other planning aspects of education and tax incentives.
The public sector called upon industries and businesses to invest in formal – and in particular non-formal – STE, to provide expertise, to engage in exchange

programmes and bursary schemes, as well as to establish funds and support the establishment of centres of excellence.

A large number of already ongoing – but, so far unrecorded – PPP activities in the region were presented during the meeting and are mentioned in this report. We hope they will serve as good examples for further initiatives to come.

Julia Heiss
UNESCO, Paris, July 2004

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Executive summary

This document was prepared following a sub-regional workshop on private sector partnerships for improving the quality of science and technology education held in Windhoek, Namibia, from 28 to 30 July 2003. The workshop was attended by representatives of the public and private sectors of eight countries in the SADC region. The document attempts to bring together ideas emerging from the workshop into a format that will be of use to policy-makers and curriculum developers alike.

The report consists of five main sections. Points in italics reflect the main issues and recommendations that emerged from the workshop.

1. An overview of science and technology education in the region

A number of factors contribute to the failure of the system to produce scientifically qualified learners in the numbers desired. This report section pinpoints a number of key issues associated with the capacity of the system, the schools and the teachers, and also with the curricula.

2. An overview of technical and vocational education in the region

The capacity of the current system to respond to current changes in the needs of industry is examined, particularly the moves towards competency based training. The implications of the current shift in the centre of gravity of technical training from secondary to post-secondary are raised. The changes in instructional practices consequent on the introduction of ICT are also examined.

- *New models for TVET both in school and beyond are emerging in the region, and these are listed.*

3. Specific issues in science and technology education in the region

The workshop looked more specifically at a number of the key issues associated with the production of science teachers in both the required numbers, and of the desired quality. A number of recommendations emerged.

- *Curricula are currently overloaded and many are under review. Some principles are recommended for this task, particularly in the light of curriculum changes as a wider ability range is admitted to senior secondary schools.*
- *The large gap between the intended and implemented curriculum was a cause for concern, particularly with regard to the place of practical work. A number of proposals are made that address teaching and learning issues, teacher education and support, and equipment provision and maintenance.*
- *Access to good science programmes is currently inequitable and discriminatory, and a number of proposals are made for addressing this.*
- *Assessment practices currently neither match well the goals of the curricula, nor serve the teacher and learner in monitoring progress. Some improvements in assessment practices are proposed.*

4. Facilitating effective partnerships between the public and private sectors

Although there were many examples in the region of private participation in public education, they are generally little known and uncoordinated. For an expansion of effective co-operation, in which optimum use is made of what both have to contribute, the two sectors, particularly the public sector, must re-examine their traditional roles in the supply of educational services. A number of ideas and proposals emerged from the workshop.

- *Enabling legislation will be needed for the private sector to play a greater and more integrated role. The South African Schools Act of 1996 provides a useful model. A key element of any legislation must be the devolution of management and budgetary control to school board level.*
- *An information-gathering exercise is necessary in each country, both to uncover the extent of existing public–private partnerships, and also to identify and study promising practice.*
- *Consideration should be given to a gradual shift in the traditional roles of all concerned in the supply of education towards a more demand-driven model where the role of the state shifts from that of a supplier to that of procuring and monitoring. This would open the way for a much more effective private sector involvement.*
- *The perception of the role of the private sector in public education must shift from that of a supporting role to that of a central player.*
- *A co-operation agenda should be agreed at the highest level between the two sectors.*
- *Study bursaries are provided by many private sector institutions. The establishment of regional centres for specific fields of study would make better use of scarce resources and would be in line with SADC policy.*
- *Industry-wide educational support funds allow companies with a common interest to combine their efforts. A fund secretariat makes the administration of such support more effective.*
- *Tripartite partnerships offer an effective mechanism for educational support. In this model, a funding agency teams up with a private*

educational service provider to offer a service to one or many educational institutions.

- *Examples exist in the region of effective public–private partnerships in programme design, development, teaching and monitoring. These should be analysed, and good practice replicated.*
  There are many examples in the region, particularly in South Africa, of private sector support for the public promotion of science and technology. Science centres, road shows, competitions and award schemes all have a positive impact on the health of the science education sector.
- *Pilot initiatives, such as joint-venture schools, are needed in order to gain experience of how effective partnerships might work.*
- *Centres of excellence in science and technology either exist or are planned in the region. These constitute a coincidence of interest between the two sectors that could form the basis of pilot initiatives.*

5. Networks and forums for science and technology

A number of networks are in place linking science and technology education professionals in the region. Some are small minority initiatives by groups of friends and colleagues. Others are initiatives of bodies such as UNESCO. Still others are professional associations – such as the research association, SAARMSTE and the body representing science centres, SAASTEC.

Little use has so far been made either nationally regionally of electronic means for linking science professionals or of websites that offer them a professional service. Initiatives beginning in several countries, however, could change this rapidly as the need grows.

Workshop report

A report of the workshop is included in Appendix A.

Introduction

Background

This document was prepared following a sub-regional workshop on private sector partnerships for improving the quality of science and technology education held in Windhoek, Namibia, from 28 to 30 July 2003. The workshop was attended by representatives of the public and private sectors of eight countries in the SADC region, Angola, Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland and Zimbabwe. The document addresses the main issues debated at the workshop, and also attempts to bring to these issues ideas from a variety of sources including current research in the region as well as ideas emerging from the workshop, into a format that will be of use to policy-makers and curriculum developers alike.

The document addresses a fundamental issue common across the African continent: how to develop an education system at senior secondary level that produces science and technology students of sufficient quality, and in sufficiently large numbers, to satisfy the growing need as countries gradually move from economies based mainly on the export of raw materials, to economies that are based increasingly on added value given to those raw materials. This is a process that requires a growing scientifically and technically literate workforce.

This change is a particularly difficult one because the necessary government funds for developing such quality senior secondary education will only be forthcoming, in any substantial way, after the economic change has begun to take root. The provision of senior secondary education for the majority is something few African governments can currently easily afford. The workshop examined mechanisms for improving the quality and quantity of scientifically literate students and also innovative ways by which resources might be mobilized to meet the demands of these mechanisms.

The report

The report consists of five sections.

An overview of science and technology education in the region
This looks very broadly at the state of science and technology education in the region and identifies a number of issues, many of which were further discussed at the workshop and are elaborated in subsequent sections of this report.

An overview of technical and vocational education in the region
This section looks at the current state of post-secondary technical and vocational education in the region and identifies a number of key issues.

Specific issues in science and technology education in the region
This section examines, more closely, a number of the issues raised in the first two sections and details a number of proposals that emerged from the workshop.

Facilitating effective partnerships between the public and private sectors
This section looks at the current mechanisms by which the private and public sector work together in the furtherance of science and technology education in the region. It also examines ways in which systems could be changed to make partnerships more effective. Finally it proposes a number of mechanisms that emerged through the workshop for building on this existing co-operation.

Networks and forums for science and technology
This examines existing regional networks for science and technology teachers, good practice here and elsewhere on the continent, and proposes some new initiatives.

Workshop report
A report of the workshop is included in Appendix A.

1. An overview of science and technology education in the region

The workshop reviewed the current state of science and technology in the region. Although differences between countries were recognized, important common issues emerged. These fell broadly into four categories concerned with the following areas: (a) the capacity of the system; (b) the capacity of the schools; (c) the capacity of the teachers; and (d) the curriculum.

The capacity of educational systems

The capacity of educational systems to support desired developments in science, technology education, particularly at secondary level, is currently limited by a number of factors. These mainly relate to cost, to inequitable access to good schools, to the shortage of science teachers, and to the shortage of learners wishing to study science.

Meeting the cost of the expansion of secondary education

A major issue is the ability of systems to meet the likely costs of the expansion of secondary education. Table 1 sheds light on the likely costs of increased enrolment in secondary education in Africa as a whole, compared with a similar exercise in Asia and Oceania. The cost for countries in the region that have all achieved a Gross Primary Enrolment (GER1) higher than the African average, will lie somewhere between these two figures. A challenge for all countries is to develop effective senior secondary systems with per capita costs that are not significantly higher than primary systems. This section looks at some of the factors that influence this cost.

Table 1. The financial challenge of increasing secondary enrolment

	GER1	*GER2*	*Education expenditure and % GNI*	*Secondary education as % GNI*	*% GNI needed for GER2 of 80%*	*% GNI needed for GER2 of 80%*
Africa	85.9	28.2	5.8	1.4	5.1	6.3
Asia / Oceania	99.9	51.4	4.2	1.2	2.0	2.5

Source: K. Lewin and F. Caillods, *Financing Secondary Education in Developing Countries*, Paris, UNESCO / IIEP, 2001.

Table 2 gives some statistics from the workshop countries. This table shows that most countries in the region spend a relatively large proportion of their annual budget on education, and the education expenditure as a proportion of Gross National Income (GNI) is also high. However, because a very large proportion of educational expenditure is accounted for by the salary bill (81 per cent in the case of Namibia), little is left over to support expensive

subjects such as science and technology. No country comes near the level of expenditure needed, according to Table 1, to support secondary education for all up to grade 12.

Table 2. Some regional educational statistics

	Botswana	*Lesotho*	*Malawi*	*Namibia*	*South Africa*	*Swaziland*	*Zimbabwe*
Learners	488 801	252 035	3 264 128	528 958	12 000 000	223 399	3 400 717
Schools	1 042	1 226		1 545	29 000	723	6 294
Teachers	22 738	12 052		18 117	350 000	10 206	101 889
Years per phase	7 - 3 - 2	7 - 3 - 2	8 - 2 - 2	7 - 3 - 2	6 - 3 - 3	7 - 3 - 2	7 - 4 - 2 (to A-level)
GER pr (%female)	111.4 (49)		(48.4)	89.1 (51)	121 (G3-9) (49)	134.5 (44)	107.9 (50)
GER JS (%female)	92.3 (52)			48.3 (G812) (59)	87.33 (57)	46.8 (46)	48.5 (45)
Education expenditure as % TGE	30.1 %		28 %	31.7 %	21 %	30 %	18 %
Education expenditure as % GNI	7.8 %		6 % (1997)	8.4 %	7 %		7.5 %

Source: Latest national data, from 1997 to 2002.

Unless countries in the region experiences substantial economic growth in the near future, any significant change in the quantity and achievement level of learners leaving the senior secondary system will require a fundamental reassessment of ways in which the system is financed and supported. Additional resources must be mobilized from parents, communities, non-governmental organizations and the private sector in a more effective manner than has been the case in the past. This issue is examined further in Section 5 of this report.

Equity and access

Regional disparities exist in most countries – usually between urban and rural areas – and these are complicated in some southern African countries by ethnic disparities.

Equity is a particularly significant issue in Namibia and South Africa where the picture is complicated by the legacy of the past. The better schools still tend to be the ones that formerly served the white community and which now serve, by reason of their catchment areas, a new elite based on socio-economic status. One reason why these schools remain lead schools is that they have retained their links with private sector resources and are also able to charge relatively high (voluntary) fees. This, in turn, feeds morale and enables them to attract the best teachers. Creating schools elsewhere that match these is proving a long and difficult task, and one consequence of this is that the private scientific sector is reporting difficulties in recruiting the numbers of staff they need from the previously disadvantaged communities. In essence, in terms of science and technology, these communities remain disadvantaged.

A number of countries are choosing to address the issue of the shortage of senior secondary graduates with good marks in science and technology by establishing centres of excellence, or encouraging them to evolve. Inevitably these tend to be in urban areas, often serving specific industries – such as the needs of a mining town – have limited boarding facilities to reduce expense, thus contributing further to the urban–rural disparity.

Unit costs

Unit costs of secondary education compared to primary appear to vary considerably. There are many contributory factors, many of which could be readily addressed. Some factors, such as the high cost of boarding, will reduce automatically as the system expands. This issue is elaborated in Section 3, where it is noted that small school size and uneconomic deployment of staff are other common factors.

A significant cost factor of particular importance in science and technology is the nature of the programmes offered. Systems such as A-levels tend to involve a large number of electives taken individually by small numbers of students pursuing a small number of subjects to a greater depth. These are inherently considerably more expensive than systems that require a broader field of study with less depth and that offer less choice. This is amplified in the case of science subjects because the greater depth of study offered by science A-levels requires more costly equipment and facilities. There is currently a worldwide trend away from in-depth studies at this level matching the growing demand for full-time education for all for 12 or 13 grades. Ghana, Malawi and Nigeria are examples of African countries that have made this move in recent years.

Table 3 shows a spectrum of courses ranging from the most ex-pensive on the left to a programme on the right that can be, if run well, self-financing through the sale of produce.

Table 3. Science courses showing typical level of facilities and equipment required

Syllabus	*A-level physics*	*Grade 12 'selective intake' syllabuses*	*Grade 12 'science for all' syllabuses*	*Grade 10 'life science'*
Typical practical require-ments	Class size - 24 Fully serviced laboratory with low-voltage systems, expensive demonstration equipment and 6–12 sets of equipment covering all main topics	Class size - 36 Serviced laboratory, including gas and low-voltage systems, 6–12 sets of basic equipment and materials, and access to demonstration equipment	Class size - 40 Serviced room, preferably with gas and access to 6--12 power packs or a supply of batteries. Supply of basic materials, much of which will be commonly available locally	Class size - 40 Room with a working sink, class sets of sim-ple equipment, heating equipment and some common chemicals, gardening equipment and secure garden area

Enrolment and repeat rates

Higher enrolment rates reduce unit costs. Higher enrolment rates also reduce gender disparities; countries with significantly less than 100 per cent GER in the primary phase all have significantly greater gender disparities in secondary GER than those that have full primary enrolments (see Table 2).

A reduction in repeat rates allows higher enrolment, lower unit costs, and results in lower gender disparities. However, alternatives to repeating involve complex issues of differentiation in the curricula and in learning materials, of school organization to address the needs of faster and slower learners, and of teacher education and support. These issues have not yet been addressed comprehensively and in depth in the region (see 'The Implementation Gap', Section 3).

Retaining science and technology teachers

A shortage of good science and technology teachers at all levels was widely reported. This was partly due to a failure to train teachers, but also to a failure to retain them. Several contributory systemic weaknesses were identified: (a) failure to attract sufficient qualified graduates into the profession with mechanisms such as additional salary increments; (b) no mechanism within the conditions of service to either recognize or reward good teaching and so retain such teachers in the classroom; (c) no mechanism to link salary increments to professional development activities; and (d) considerable differences in salary scales within the region tempting teachers to higher salaries across borders. This issue is addressed further in Section 3.

Capacity within schools

Lack of management capacity in senior schools was identified as a major factor inhibiting the emergence of good science teaching. This has many facets among which are:

- A failure to ensure sound professional support for teachers, particularly young ones.
- A failure to overcome the ubiquitous school culture that labels attempts at radical changes of teaching methodology by potentially innovative (often young) teachers as unacceptable and inappropriate.
- A failure to understand and support the needs of science teachers and of the science subjects.
- Poor internal efficiency caused by poor management skills, particularly in areas such as time-tabling.
- A failure to acknowledge the need for mechanisms for dealing with wide ability ranges.

This weakness is recognized and ministries are addressing it through a variety of mechanisms such as management training, whole school training and the establishment of cluster mechanisms that encourage the weaker to be assisted by the stronger. The United Republic of Tanzania, for example, has put in place a whole school training programme with a specific science focus.

Improving efficiency

Little information is currently readily available on individual school efficiency. Although examination results are published, these are not processed in a manner that allows clear judgements of individual school efficiency by the general public. The cost of a 'pass grade', however that may be defined, is generally unknown. Evidence produced by external analyses suggests that this cost may be, for most countries, unacceptably high.

A number of indicators are available that provide information on the internal efficiency of secondary education. Repeat rates, gross enrolment ratios, pupil/staff ratios and drop-out rates, are available but are published usually only for states or provinces or regions within countries, and not for individual schools. Other issues that impact on efficiency such as time-on-task, teacher absenteeism (from the school or from the classroom) are not measured. Available statistics suggest that there is potential for considerable improvement in the output of the sector simply by addressing these issues at a school level. A study in Namibia suggested that simple improvements in time-tabling techniques and option choice arrangements could lead to much more effective utilization of capital facilities and the teaching force.

There is a need to set clearly defined efficiency targets, identify areas of inefficiency and assist schools to overcome them.

It is likely that the HIV epidemic will have an impact on efficiency, particularly through absenteeism from the classroom. Evidence from Botswana and from an education sector impact study in Namibia suggests that the provision of anti-retroviral treatment will greatly reduce this.[1]

Accommodating the needs of a wider intake into senior secondary education

One consequence of an expanded intake into senior secondary education is that option choices must be widened to take into account both the personal ambitions of the learners and also the necessity to offer a programme for the new wide ability range that will enter the schools.

Two mechanisms are available to accommodate this widened intake. One mechanism is to offer a variety of different kinds of secondary schools established with differing focuses – there is already a tradition of this in the region with the senior secondary technical schools. These have suffered, however, because they have been seen as second-class schools, and their clientele have tended to be those who have failed to get into 'better' schools rather than those particularly seeking a technical education. They also have a reputation of being very expensive to operate.

The alternative choice is to increase the size of secondary schools. Currently these tend universally to be small, seldom with more than 600 students. Schools of this size have provided an efficient service in the past because they did not have to offer a wide choice of subjects and levels of study to their highly selected intake. In the future, non-selective secondary schools must be

1. A. Kinghorn et al., *The Impact of HIV / AIDS on Education in Namibia*, Windhoek, Ministry of Basic Education, Sport and Culture, 2002.

larger if schooling is to be affordable and cater for all. The size will clearly depend on the breadth and depth of options offered. The Namibia efficiency study suggested that schools smaller than 500 or 600 tend to be inefficient, resulting in small groups and teachers teaching subjects in which they had little competence. Schools of 1,000 learners and more must increasingly become the norm if little selection is imposed and teachers and facilities are to be used optimally. This, in turn, will present new management challenges.

Empowering school management

It is argued in Section 4 that a necessary prerequisite for effective senior secondary education is devolved management. This argument is partly empirically based on the observation that, in the region, there seems to be a correlation between the effectiveness of a school and the degree to which it is able to control its own affairs. We must not be over-surprised at this; schools that have management teams that are able effectively to control a budget, in some cases running to the equivalent of millions of rand, are probably also likely to be able to manage equally well issues such as professional development and classroom support. Table 4 lists a number of characteristics that can usually be readily identified in a well-performing school.

All the activities in Table 4 are characteristic of effective corporate management. All are more likely to happen in an institution which has its own clear identity rather than one in which teachers see themselves as merely staff that happen to be manning the local branch of the Ministry of Education.

Table 4. Some characteristics that can usually be identified in a well-performing school

School	*Strong sense of mission*
Parents	Good contacts with parents Strong parental involvement in fund-raising activities
Management	Many afternoon activities Clear departmental policies Effective pastoral care policies and structures Optimum class sizes Variety of choice accommodated skilfully into the time-table
Staff	Good staffing efficiency resulting in congenial staff time-tables Staffing that matches needs so that most staff teach their best subject most of the time High morale among staff, both teaching and ancillary Well managed staff development and support programmes
Teaching en-vironment	A strong sense of order and control without oppression Clean, attractive and respected environment that is conducive to work Optimal use of physical facilities A well-stocked and managed library, most probably enhanced by internet access, and a pro-gramme that teachers learners how to make use of it.

School science departments

A key characteristic in Table 4 is that of clear departmental policies. How a department is managed crucially affects results in the subjects. In some counties in the region (Namibia and South Africa for example) the concept of a department is not yet clearly defined in many schools; departments tend to be loose groups of subjects combined for administrative purposes, and the number of departments tends to be determined not by academic needs but by the number of promotional administrative posts available to the school. There is a need to define clearly the nature and role of a science department if science subjects are to be taught effectively.

Accountability

The notion of the 'nanny' state in which educational systems are managed secretively, on behalf of the people, by administrators behind closed doors, dies hard in the region, despite the almost universal advent of democratic systems. Statistical details describing educational systems, although available, are often still not easy to obtain and key documents relating to individual schools (such as inspector's reports), remain confidential. Although indicators like examination results are usually published, they are seldom collated in a manner useful to parents (except, of course by those schools that do well), or indeed anyone wishing to make interschool comparisons.

The degree of accountability of teachers to their communities varies throughout the region. Some countries have established performance appraisal systems but, generally, throughout the region a teacher has a job for life, and progression up what salary scales there are, is, for the most part, automatic. There are a number of grounds for dismissal of a teacher but inability to teach is not usually one of them. Rewards for good performance are undeveloped or underdeveloped, and if good teachers aspire to higher salaries, they must leave the classroom. This issue was examined at the workshop and is discussed further in Section 3.

Teacher capacity

Figure 1 represents a common feature of the region that has remained obstinately evident despite massive inputs of donor funding to address it. Students entering colleges and universities to follow teacher education courses tend, generally, to be weak, particularly in science and mathematics, primarily because they have been taught by teachers who themselves are weak in content, and teach mainly through lecturing or simply reading from a textbook. They are also weak because, in general, it is the weaker students in mathematics and science who choose, often reluctantly, to go into teaching.

Courses offered in the colleges and universities tend to do little to rectify this and often fail to change either the mastery of content or the teaching methodology. These teachers then enter schools, teach in the same way they themselves were taught, and so perpetuate the cycle.

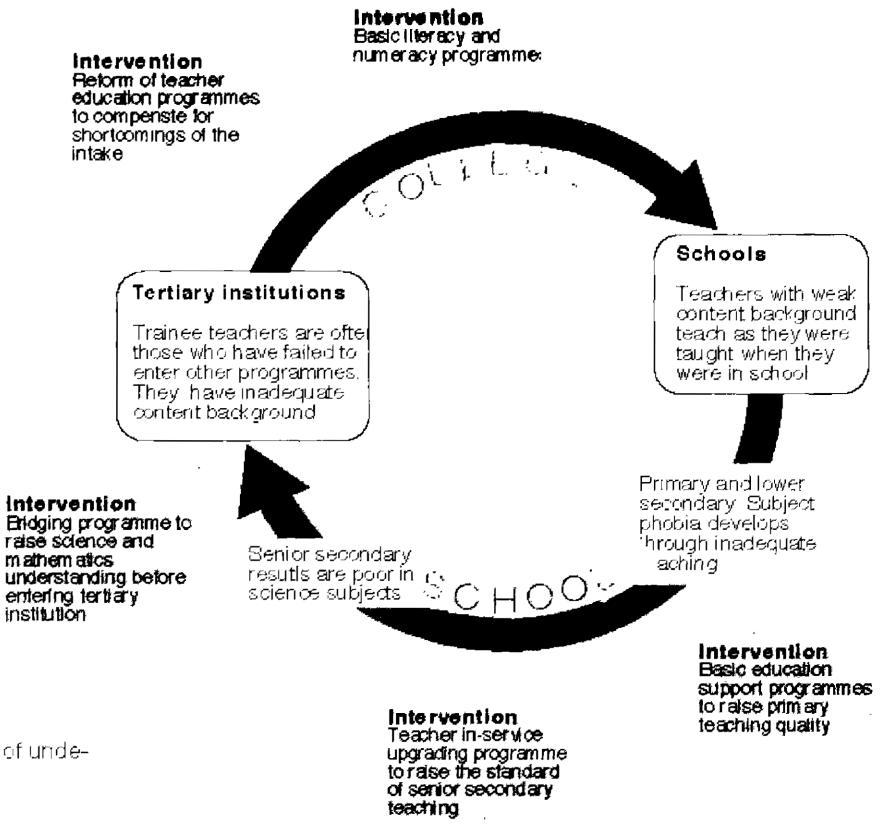

Figure 1. The cycle of underachievement

Breaking the cycle

There have been a number of attempts in the region to break this cycle. Many are shown in Figure 1, but it seems to be extraordinarily resistant. There is evidence from several countries that the most effective tactic has been a bridging programme between secondary and tertiary education to remedy deficiencies. These are, however, expensive and long-term, often lasting for up to twenty years.

Countries such as Botswana, where the academic year of the tertiary sector does not correspond with the academic year of the secondary sector, were able to fit the bridging programme into the gap of several months between the end of secondary and the beginning of tertiary. In other countries, the bridging programme is often built into the first year of the tertiary phase, as with the Polytechnic of Namibia. This is often the strategy adopted by some colleges of education which operate intensive literacy and numeracy programmes as part of their first year. In South Africa, individual tertiary institutions, recognizing the potential of the many school-leavers who have underachieved because of failures in the system, have created such bridging programmes as mechanisms for ensuring their market share of good students.

Much is known about this issue and it is elaborated further in Section 3 of this report, which examines in greater depth mechanisms for addressing it.

Expatriate teaching forces

A dilemma faced by many countries wishing to increase access to senior secondary education is that teachers are only available in sufficient numbers

after the event. This means that foreign teachers have to be employed, an issue fraught with a number of problems: (a) the quality of foreign teachers is variable and usually cannot be determined until after the teacher is in place; (b) the high turnover of such teachers results in a lack of continuity of effective teaching; (c) the teachers may have been trained for a system that has very different objectives, methodologies and assessment techniques from the host country; and (d) teachers often come from within the region, attracted by higher salaries, undermining successes made by the country from which they have come. These problems can be greatly magnified if the foreign teachers are employed as teacher trainers.

It must also be noted, however, that many foreign teachers are excellent practitioners, and bring to the host countries new expertise which they willingly share with their local colleagues.

The curriculum

Wide dissatisfaction with existing science and technology curricula was noted at the workshop. The issues identified fall broadly under several headings: (a) curriculum overload; (b) the mismatch between the intended and the implemented curriculum, manifested *inter alia* in high failure rates and other quality-related issues; (c) inappropriateness of the content; and (d) lack of clear policy guidelines to direct curriculum design.

These specific issues, all related to the detail curriculum design and implementation, are discussed in more depth in Section 3. One overreaching issue that must be further addressed by all countries as access to senior secondary education expands, is the structure of the curriculum as it changes to meet the needs of a wider ability range.

Curriculum structure

There are significant differences in senior secondary curricula in the region. Zimbabwe has opted for A-levels, characterized by a small number of subjects studied in depth and ending normally after the thirteenth year of schooling. The other countries have opted for a broader curriculum ending in the twelfth year. These two systems mirror options elsewhere in the world, the former being broadly characteristic of Europe and the latter of the United States (and also Scotland). As the TIMSS[2] studies have shown, there is surprisingly little basic uniformity between science curricula worldwide, particularly not the curriculum as it is revealed in the classroom.[3]

As was noted earlier, choice of curriculum has considerable cost implications.

Senior secondary curricula in the region have, in the past, catered for only a minority of the age cohort selected on ability. The South African Matriculation Examination was typical. New curricula must incorporate mechanisms that allow for a broad range of ability. Typically this will involve (in science) any or all of the following mechanisms: (a) different programmes of study for different purposes; (b) differentiated learning objectives within the same programmes of study ('core plus options'); and (c) differentiated examination papers discriminating between different grade ranges.

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2. TIMSS, Third International Mathematics and Science Study, an international comparison of science and mathematics performance at secondary level. South Africa was the only country in the region taking part. The study has led to a wealth of analytical papers by a variety of teams, worldwide.
3. See, for example, L.S. Cogan et al., 'Culturally Specific Patterns in the Conceptualization of the School Science Curriculum: Insights from TIMSS', *Studies in Science Education*, Vol. 36, 2001, pp. 105–134.

Throughout the region these reforms are gradually taking place, and there are some striking differences of approach between countries (see Section 3). Of particular interest is the South African outcomes-based curriculum which allows devolution of many aspects of the curriculum to provinces and even to the schools.

Linked to senior secondary curriculum restructuring is the issue of whether some form of mathematics and science should be compulsory at that level. Decisions on this will have considerable implications for cost, facilities and teacher education.

2. Overview of technical and vocational education in the region

The workshop examined the current issues related to technical and vocational education in the region. A strong thread running through all contributions was the recognition that the traditional practices were no longer meeting the rapidly changing needs of the clientele.

Responding to change

For over a century car engines were tuned by mechanics with screwdrivers. Today's car engines are tuned by mechanics with lap-top computers.

The magnitude and suddenness of this change, which is representative of changes across the TVET spectrum, has left the bureaucratic, supply-driven, government-controlled, traditional certificate programmes, unable to satisfy to the changing needs of industry, unable to find appropriately experienced instructors, and unable to provide industrial placements for its trainees. Conversely, the nature of long, comprehensive traditional certificate qualification has meant that many of the grass-roots training organizations, dedicated to satisfying local needs with short, highly specific and targeted courses, produce trainees that currently have no formally recognized qualifications.

Moves towards competency-based training programmes linked closely to demand are, however, taking place in the region, often led by industry-based institutions. Much TVET is carried out through in-house programmes run by the larger companies. Both these kinds of programme are more responsive and demand-driven but the system is still often characterized by a lack of co-ordination between institutions, a lack of an appropriate overall competency-based qualification framework and a lack of the necessary institutional structures to ensure proper management, financing and instructor training. Strategies for addressing these issues are, however, under development and a system of regional competency based standards is under discussion.

A significant characteristic of the solutions under discussion is a major shift in the role of government away from that of a supplier to that of a purchaser and facilitator, and a shift in the management and control of programmes away from government alone to the consumer, through majority representation on training councils. Increasingly, it is likely that training institutions will be privately owned and managed, often serving specific industries, and the role of government will contract from that of management to that of a co-partner, or junior partner, on a management board.

Governments may continue to finance the system through bursaries, or that function could be taken over by a payroll training levy on companies that benefit from the training, but do not themselves provide training opportunities.

Should TVET be a component of the secondary phase?

Traditionally in the region, technical education was primarily incorporated into the secondary system, either as elements of the normal curriculum or, more frequently, into special technical schools set up with workshops and other facilities. The curriculum followed in these institutions was a blend of the normal one, examined through the same system, and a technical one examined through a technical system.

The nature of the technical bias in the technical school was often deliberately tailored to the needs of the community or region. In rural areas, for example, there was typically a bias towards agriculture. Movements such as the Brigades in Botswana, pioneered the philosophy of 'Education with Production' in which, in its pure form, the school paid for itself from contracts to the local community.

A major limitation on the development of technical education in schools has been both the capital and running costs of the workshops, and the staffing of the smaller groups dictated in part by safety regulations, but mainly by low take-up of some of the programmes.

More recently, partly because of the move towards a basic education for all, TVET has moved substantially into the tertiary phase where more extensive facilities can be used (in principle) more economically. There is evidence in some countries, however, that certain curriculum elements associated with technical education, such as child care, home economics and hairdressing, which served certain industries and professions well, have become rather lost in the change.

Technology education in schools

Unlike science, technology in schools in the region has only recently come to reflect worldwide changes in the subject in recent years. Perhaps because of the tradition of special vocational schools, the majority of schools in the region offered few, or no, technology based vocational courses and, when they did, they were subjects such as technical drawing or craft subjects, with domestic science – in effect if not explicitly – for girls.

With the recent expansion of 'Education for All' into junior secondary level, there is a move to replace vocational programmes in schools with pre-vocational programmes that offer a broader based programme not focused on any particular vocation or craft. Associated with this trend is the movement to replace the traditional craft-based school courses at senior secondary level with design-led programmes that are also more pre-vocational than an end in themselves. As with science subjects, however, a gap remains between the intended and the implemented curricula, and traditional methodologies hold sway. These programmes remain minority ones offered by few schools, partly because they are relatively expensive on resources. Botswana is an exception.

Design and technology in Botswana

A significant exception and a promising practice in the region is in Botswana where a design-driven technology programme is now a compulsory component of the junior secondary programme for both boys and girls. A

strong teacher education programme has been created to support it. The programme is backed by special facilities that are constructed in every school and by a specific capitation allowance of 70 pula (about U.S.$20) per learner per year for equipment and materials.

It is a popular course (as such courses almost always are) and there is anecdotal evidence that it improves employment prospects of the learners. The heart of the programme is design and the problem-solving process includes elements of drawing (communication) and also entrepreneurial elements such as costing, advertising and marketing.

ICT is being built into the programme, as is electronics and microelectronics, but both raise problems related to teacher competency at this stage.

The box, 'New Models for Technical and Vocational Education and Training', summarizes developments.

ICT in schools

In general, ICT is currently perceived by schools and parents alike in the region in the rather limited terms of 'computer studies', which has replaced 'typewriting' as a vocationally directed study.

New models for technical and vocational education and training

Many countries in the region have put in place a re-examination of their technical and vocational education and training programmes in order to make them more responsive to the changing needs of their industrial sectors. Inevitably, the private sector – the consumers – have been involved heavily in the process, and new models are evolving in which public–private partnerships are built in.

Elements that feature in some way in many of the evolving TVET systems in the region are:

- Private management of training institutes established by industry and financed jointly by government and the private sector, or through a training levy.
- The development of regionally recognized competency based skill standards that are closely linked to the needs of the private sector.
- The development of management structures for TVET which are answerable to a board on which the private sector is represented, perhaps in the majority.
- The evolution of small, village-based training institutions, locally managed and responsive to the immediate needs of the community, together with a competency based qualification system which will allow their trainees to receive some kind of qualification that is a step on the vocational ladder.
- The evolution of institutions whose primary objective may not be training, but which nevertheless provide training for school-leavers which can be recognized by training institutions offering courses at a higher level.
- The development of a training levy system on the payroll of companies, which is sufficiently flexible to reward companies offering their own training.
- The shift of the centre of gravity of vocational training from the secondary to the tertiary system.
- The development of a new generation of learner-centred design-led technology programmes and prevocational programmes in schools.
- The establishment of a regional TVET centre in Botswana.

Two recent reports[4] into ICT in education in the region, have shown that in adopting ICT both as a subject and as a teaching and learning resource, most countries had made a start but progress was varied. As may be expected, South Africa was in the lead both in terms of the proportion of schools with computers (now reaching 25 per cent) and in the development of useful

4. L. Chisholm et al., *The Use of ICTs in the Curriculum with Reference to Case Studies in Botswana, Namibia and Seychelles* (draft presented to the EPSI meeting, Zanzibar, August 2003); W. Ottevanger et al., *Science, Mathematics and ICT (SMICT) in Secondary Education in Sub-Saharan Africa, Trends and Challenges* (First Conference on Secondary Education in Africa (SEIA), Kampala, Uganda, June 2003).

electronic teaching and learning materials. One significant characteristic was common to all countries studied; not one yet had a comprehensive ICT in education policy, although South Africa has, at the time of writing, a draft white paper under discussion. Table 5 shows major trends in the use of ICTs in the countries of the SEIA study.

There are numerous moves in the region to exploit the teaching learning and assessing possibilities opened up by the exploitation of ICT in schools but as yet the considerable efforts of champions both within and outside the system, has not yet succeeded in pushing this learning aid over the 'activation barrier'.

Table 5. Trends in instructional practices related to

Computer studies	Computer studies has found its way as a subject into the formal curriculum of all countries. In most educational practice, computer studies are embryonic, mainly due to lack of computers, connections and staff expertise. There are exceptions, mainly clustered in resource centres, pilot schools and teacher training institutes.
Teacher training and support	ICT is incidentally used for in-service training of science and mathematic teachers in the form of networks. These networks deal with science and mathematics education as a whole, not just ICT education.
ICT as a teaching and learning aid	ICT is only incidentally used in Mathematics, Science and Technology education in a targeted way, extending the possibilities for teaching or learning MST and improving the quality of MST education. Most successful in the implementation of ICT in practice use are a few, often donor funded projects, of which SchoolNet Africa and WorldLink stand out because they are active in several countries, and because they combine support in three layers: infrastructure (ICT hardware), general and educational software and the training of teachers. Often the projects focus on ICT centres or resource centres (Zimbabwe) or a small network of pilot schools. The focus in terms of ICT as a means to enhance the quality of education is often very vague.
ICT in Education policy	Though all survey countries have national programmes for ICT in curricula, and material provisions for schools and teacher training, most of the countries lack national umbrella organisations watching over a co-ordinated implementation. A characteristic quote from the Namibian country report: 'What is currently absent from ICT developments is any well formed umbrella coordinating and facilitating organisation or any ICT in Education policy directives, of the kind that are a normal feature of ICT in education in the developed countries, and are a normal feature of most elements of education everywhere. The ICT education environment is characterised by a multitude of individual independent developments which individually have been exceptionally productive. There is need now, however, for the development of shared vision and sense of direction.'

3. Specific issues in science and technology education in the region

This section examines specific issues in science and technology education that were raised at the workshop. It makes a number of suggestions and recommendations related to the issues, some of which emerged from the workshop discussions, and others are drawn from information that has emerged from other studies including, in particular, the work being conducted by researchers throughout the continent as part of a thematic study of secondary science, technology and ICT promoted by the World Bank as part of their Secondary Education in Africa (SEIA) initiative.[5] Four of the countries represented at the workshop (Botswana, Namibia, South Africa and Zimbabwe) also took part in the SEIA thematic study.

One important conclusion that has emerged strongly from the SEIA study is that most problems are continent-wide. Any significant difficulty experienced by one country is probably present universally.

The science curriculum

In all countries in the region, science and mathematics are compulsory subjects until the end of junior secondary education, which for most countries in the region, is the level attained by most students. In all countries in the region, no more than 60 per cent of students carry on in school through the senior secondary grades and in no country is science yet compulsory at this level.

Table 6 lists some of the main trends in science curriculum policy identified by the SEIA study, and some of the issues are elaborated in more detail in this section.

5. The tables quoted in this document are taken largely from the first study to emerge from the SEIA study into science, 'Science, Mathematics and ICT (SMICT) in Secondary Education in sub-Saharan Africa, Trends and Challenges', by Wout Ottevanger, Mariska Leliveld and Andrew Clegg, presented at the First Conference on Secondary Education in Africa, Kampala, Uganda, 9–13 June 2003

Curriculum overload

One issue that was widely reported was that increasing demands were being made on the curricula to include new topics. These include emerging issues, topics of local relevance and societal issues. Increasingly, curricula had to carry cross-curricular themes that society deemed to be of importance, from environmental education and democracy education to HIV/AIDS education. 'Every time society has an itch, schools are expected to scratch it' (Cuban). Teachers reported widely that they had difficulty in completing the syllabus on time.

Table 6. Trends in curriculum policy

Localised syllabi and examinations	All countries have localised curricula and examinations or are in the process of localisation (Namibia).
Education for all policies,	These are widely in place and have led to problems of mixed ability teaching in most countries. To deal with this problem, some countries (Botswana, Namibia, Zimbabwe) now offer core and extended level programs within some of the SMICT subjects.
Inclusion of societal issues	New topics have been added to the SMICT curriculum, including HIV/AIDS related themes environmental education, issues related to science and technology
Integration of science topics	In all countries a move towards the integration of science topics within the SMICT curriculum can be observed, both at junior and senior secondary level. The integrated science courses contain at least a combination of biology, chemistry and physics (Botswana JSS), and can also include agricultural and environmental topics (Namibia).
Inclusion of ICT	In most countries Computer Studies has been introduced as an optional subject at both junior secondary and senior secondary level, but there are numerous implementation problems.
Emphasis on learner-centred education	In all countries moves have been made emphasising more active learning approaches in the SMICT curriculum.
New ways of assessment	Most countries have made attempts to introduce continuous formative assessment as part of the examination. Changing the norm-referenced examination practices into a wholly criterion-referenced assessment system is currently being considered in a number of countries, but only three countries have turned it into a policy priority yet (Botswana, Namibia, South Africa). Namibia and South Africa have also introduced new ways of grading.

Closer analysis, however, suggested that the issue may not necessarily be overload, but may be that necessary prerequisite work had not been covered adequately, requiring time to be spent on work that should already have been done. This is usually blamed on poor teaching at an earlier level. Evidence from some countries suggests that the fault may be just as much with the curriculum which specifies too much in early stages of the spiral. This creates the erroneous perception that the subject is more difficult than it really. Subject 'phobias' generated in this manner are notoriously resistant to cures. The box 'Some Principles for Reviewing Curricula' makes some suggestions on how to eliminate these problems.

The greatest challenge facing curriculum developers remains, however, not what to put into a curriculum, but what to leave out.

Some principles for reviewing curricula

1. **Curriculum reviews should be comprehensive and not piecemeal**. The review should focus on the whole curriculum from Grades 1 to 12. The first exercise should be to establish the scope and sequence of each element within each topic.

2. **There should be a strong focus on basic principles of numeracy and literacy in the early years**. Subjects such as science should best be seen as vehicles for teaching numeracy and literacy at this stage.

3. **Close attention should be paid to language issues.** In many countries there is a change in language of instruction at some stage. This raises two issues. The first is that the curriculum should be designed in such a way that it does not make impossible demands on the home language when the subject is taught in the home language. The second issue is that the first year after the change in language, the curriculum should be lightly loaded and repeat some of the major issues covered earlier in the home language. The major educational focus of this year should be mastery of the instructional language rather than the subject.

4. **Depth rather than breadth.** Analyses* of the curricula of high-achieving TIMSS countries (Japan, Singapore, the Republic of Korea, Czech Republic) show that topics in each year are kept to a minimum and are clearly linked to studies in the previous year.

5. **Each topic will be covered in a spiral manner.** The spiral must be carefully analysed to ensure that not too much is covered in early stages of the spiral, and that the spiral does not become repetition. Difficult concepts should be postponed to an appropriate year. A very good example of this is the abstract science of atomic structure which usually presents little difficulty in Grade 11, but if taught in Grade 9 or 10 takes a long time and destroys interest in science.

6. **Bring in local context at all levels**

7. **Differentiation can be built into the curriculum.** This is by using statements that indicate the expected achievement of faster, average and slower learners at each stage. This will give teachers a guide as to the minimum expected standards. It is not usually felt necessary in science to differentiate in terms of content until around Grade 10. Differentiation tends to be in terms of depth of coverage of the topic. Differentiation in mathematics content will happen earlier.

8. Differentiation above Grade 10 will involve a distinction between core content statements and 'extended' content in each topic. There may also be examples of new topics which are only part of the 'extended' content.

9. Differentiation beyond Grade 10 must also take note of the desirability of identifying content that should be part of a general education and content that should from part of a science education that leads to further studies in science. This distinction is not yet built into any curricula in the region, with the exception of Botswana. This distinction can take a number of different forms and three possibilities are shown below.

Forms of a differentiated science curriculum at Grades 11 and 1

Curriculum for general education	*Curriculum for those wishing to take science at a higher level*
Single award science	Double award science, the second award being additional to the single award
Single award science Science subjects studied at a basic level	Separate science subjects Science subjects studied at a higher level

* W.H. Schmidt, *The Quest for a Coherent School Science Curriculum: The Need for an Organizing Principle* (draft for publication). http://ustimss.msu.edu

Private sector involvement in curriculum design

No countries reported any mechanism for involving the private sector in curriculum design in the formal school sector. This has always been seen as the preserve of ministries at this level although private sector involvement in the vocational sector and in the design of tertiary programmes is becoming commonplace. This issue is discussed further in Section 4.

The curriculum web

Curricula do not exist in a vacuum; they have implications for materials design, for instructional practices, for teacher education, for equipment and for assessment. Linked to all these are cost implications. Because curricula are often driven by political rather than educational imperatives, particularly if they are part of a political transformation, this web of linked consequences tends to be ignored until, as in the case of South Africa, it becomes clear that implementation is failing. A review is then required to modify the curriculum so that the links between the components of the web can be re-established.

The message for curriculum developers is clear; trainers, writers, examiners and those concerned with budgetary matters must be part of the design process.

Differentiation; one size does not fit all

The inexorable trend within the region is towards Education for All up to Grade 12, including mathematics and science. Together with this will come automatic promotion. Current curricula do not reflect this; curricula tend to be 'one size fits all' which, in the days of 'passing the year' and selective entry into senior classes, was acceptable, but this is no longer the case. One size no longer fits all. The issue of building differentiation into the curriculum is examined in the box 'Some Principles for Reviewing Curricula'.

Science instructional practices

Learner-centred education

In all the countries, changes in instructional practices have been advocated to make the classroom more learner-centred. Universally this transition has been characterized by difficulties related to teacher professionalism and ability, teacher support and, perhaps most significantly, the failure of training institutions to change teaching habits; most teachers still teach in the manner that they themselves were taught. Because trainers often tend to be older teachers, brought up under the earlier traditions, new teachers enter the profession with similar misunderstandings. These difficulties are compounded in Namibia and South Africa where the changes have been sudden and recent and, particularly in South Africa, rather drastic. Table 7 summarizes the main issues to emerge from the study of instructional practices.

Practical work

A significant component of Table 7 is practical work. There is some debate amongst researchers and curriculum developers on the purpose and nature of practical work, notably in South Africa. This reflects a similar debate worldwide. There is general consensus that practical work is important both as an aid to understanding and for the development of scientific skills and attitudes. There is also a general consensus, however, that done badly, it is a hindrance rather than a help in achieving both these aims.

Table 7. Significant issues related to instructional practices

General shortage of teaching and learning resources	• Many countries report a general lack of adequate teaching and learning facilities, textbooks and pedagogical materials. (South Africa: 'because of the lack of resources in many schools, the teacher is often the learners' only resource to learning')
Interpretation of the syllabus	• Teachers are unable to select the more significant topics from the syllabus and are therefore under pressure to complete the syllabus. This prevents them from using more cooperative strategies in teaching. • A lack of understanding of the demands of the curriculum seems widespread. Teachers tend to see new curricula that put more emphasis on practical work as 'adapted versions of their predecessors' (Botswana) and classroom activities change little. And because trainers often tend to be older teachers, brought up under the earlier traditions, new teachers enter the profession with similar misunderstandings.
Issues related to textbooks	• Both locally and imported books are reported. The local books usually include relevant local examples, which are mostly missing in the imported books. Imported boos do not match the syllabus and selective reading of them is a difficult issue. • The use of informal learning materials developed by teachers and in the form of stencils duplicated at the teachers schools is widespread. In most of the countries, the ministry prescribes textbooks to schools for use by students. • The Ministry of Education is responsible for textbook supply to most schools in most countries, but in insufficient quantities. Those schools that can, make up the deficit from their own funds. • The availability of textbooks has not put a stop to the note dictation and copying
Issues related to practical work	• The purpose of practical work is not clear and this is reflected in the way it is often conducted. • There is general agreement that little practical work is being done. Reasons given for this are: - lack of equipment - large class sizes - examination pressure - lack of suitably trained teachers - lack of opportunities for teachers to learn how to do it • The most convincing reason for the poverty of practical work is lack of self confidence on the part of teachers. This is a consequence of a cycle of lack of exposure during their schooling and training, a cycle they perpetuate in their own classrooms. • Facilities for practical work vary widely and are often inadequate and even when adequate facilities do exist, as they do in many schools in many countries, poor maintenance, poor laboratory management, loss of key components and failure to replace consumables often renders them effectively unusable.

An important finding that is explicit in many of the SEIA country reports, and implicit in all, is that lack of equipment and facilities and time are not the main reasons for the absence of practical work. There are many examples of schools in the region where there is ample equipment but it lies idle. Equally there are many practical exercises in all the science subjects that require little or no special equipment, and these exercises are not being done either. The most significant element in this is teacher insecurity and this reflects on the nature of the teacher initial training and continuous professional development programmes.

The box 'Addressing Practical Work Issues' summarizes the major issues related to the conduct of practical work and outlines some mechanisms for improvement.

Addressing practical work issues

Issues related to teaching and learning

Learner centred activities in science teaching?
Analyses of modern science curricula show that they tend to address three aspects of science: (a) learning science; (b) learning to do science; and (c) learning about science. Learner-centred work will differ according to which aspect of the science curriculum is being addressed, and the table shows activities typical of each of the three.

Conventional class practical work is therefore only one of many kinds of learner-centred activities that should be part of science lessons. Note also that many scientific skills are not necessarily practical skills, but intellectual ones. Interpreting results using calculations and graphs, designing an experiment, drawing conclusions from observations, etc., are all scientific skills that learners can do in lessons, either individually or collaboratively, that do not necessarily require class sets of equipment.

Assessing practical skills
Three assessment methods are commonly used:
Continuous assessment of skills – very difficult to conduct in a manner that is consistent across schools.
Summative practical examinations – only test a limited range of skills and often limit practical work to the period immediately before the examination.
'Alternative to practical' examinations or questions – often is misinterpreted by teachers as being an alternative to the actual work rather than an alternative means of assessing it. In that learners who have had little practical experience do badly in the paper, it is a valid test instrument. Activities characteristic of learner-centred science lessons.

Activities characteristic of a learner-centred science lesson

Purpose of activities	*Characteristic classroom activities*
Illustrating concepts	• Teacher uses classroom demonstrations to help develop concepts • Some learners assist in planning and performing the demonstrations • Teacher uses specimens found in the local environment to illustrate lessons • Learners participate in clear closed (cook-book) practical work
Open-ended investigations	• Learners perform 'guided discovery' type practical work in small groups, engaging in hands-on activities • Learners encouraged to share information and ideas and to draw conclusions collectively
Mastery of scientific skills	• Learners undertake practical exercises that focus on the acquisition of particular skills • Assessment focuses skill mastery as well as conceptual understanding • Learners communicate data using tables, graphs and diagrams • Learners write a scientific report in which they justify conclusions from data analysis and can reflect on the conclusions in relation to competing theories • Learners design and do their own open-ended investigations
Learning about science	• Learners are involved collaboratively in exercises such as studies of local environmental issues, surveys of public opinion, debates, role playing, and other ways of studying the complexities of the interaction between science and society

Issues related to teacher confidence

Why practical work is not widely done

- Because of their lack of experience in doing practical work when they were taught science, teachers lack the self-confidence needed to handle scientific equipment.

- Because of their lack of confidence in handling the direction of the activities, they fear a lack of control.

- Because the prevailing school culture is that of teacher driven lessons in ordered classrooms. Any departure from this is felt by teachers wishing to try new ideas as undermining the learning traditions and ethos of the school. Resistance to such ideas will come from both other staff and from the learners themselves.

A practical work minimum curriculum

A movement coming from several countries to identify a certain minimum of simple practical activities in each subject in each year should be made compulsory. For these, complete prescriptions must be available that take teachers through them step by step. These should also be part of the pre-service education programmes.

These activities should be simple to carry out and involve equipment, perhaps of an everyday nature, that the teachers are familiar with. They should not require special laboratories. Clear assessment procedures should be linked to the activities The intentions behind this suggestion are many:

- It will ensure that a minimum amount of practical work is done and principals and inspectors can readily ensure that it happens.
- It will provide an opportunity for the teacher to overcome some of the confidence-related problems in a way that is well supported.
- It will provide some criterion referenced continuous assessment marks that have a degree of interschool comparability.

Model teacher education programmes

The methodology of pre-service programmes tends to be the content-driven lecture methods typical of academia and hence set the wrong examples and give the wrong messages. The need for appropriate reform of such programmes is widely recognized. One reform instituted in a Namibian distance programme is to employ experienced practitioners on a part-time basis to teach pedagogical content knowledge in an exemplary student-centred manner. Other developments under consideration include shifting much of the methodology training to specially trained mentor teachers in the schools.

Issues related to equipment and facilities

Practical work using everyday equipment

Experience in several countries has shown that teachers are able to handle practical work better if they are using materials that they are very familiar with. (A distinction must be drawn between using such materials per se and using such materials to improvise science equipment which is a high order skill. It is the former that concerns us here.)

Quite a number of practical exercises can be developed that use only 'common things'. Examples are the use of human muscle power in studies of work, power and energy, simple cardboard box models of houses to test the insulation properties of different roofing materials, and the use of a school garden to investigate plant growth.

Teachers will require clear guidelines on how to carry out this kind of work as it is a high order skill. It will be most effective if it is also incorporated in the learner textbook, together with clear instructions on what is required of the learner both in carrying out the activities and processing the data obtained.

Facilities for practical work

Traditional facilities designed for science in the past, which consist of serviced benches running across the laboratories are not only expensive, they inhibit much learner-centred work. The cheaper solution of services around the sides of a science room with flexible movable benches or desks in the centre is far more suitable for the more diverse modern curricula. Walk-in storage is important and this will have to take the form of two rooms if potentially corrosive chemicals, such as hydrochloric acid are used.

The implementation gap

The gap between the intentions of the curriculum and the curriculum as it is taught and learned in the classroom is a perennial problem. It is, however, an issue that has been much studied[6] and it arises from a complexity of factors that fall broadly into four overlapping categories: (a) unrealistic curriculum demands; (b) inadequate teacher expertise; (c) insufficient and inadequate teaching and learning materials; and (d) lack of a supportive teaching environment.

The first of these four categories has been discussed above. The remaining three are shown in Table 8 in a format that illustrates their characteristics at four stages of development of both teacher capacity and institutional capacity (labelled 'unskilled', 'mechanical', 'routine', and 'professional'). It follows from this analysis that the implementation gap is likely to be greatest under the circumstances illustrated by the top row of the table and least at the bottom row.

Many of these issues were raised at the workshop and a number of solutions to the problems raised by this analysis are suggested in the right-hand column. The challenge is to develop strategies for moving teachers and schools down the table towards the bottom, and an important factor in this is that all aspects should be addressed together. Experience has shown that if only one aspect is addressed without regard for the others, the exercise may achieve short-term gains but in the long term will be largely futile, as the wreckage of so many donor projects testifies.

Quality in science education

All countries reported dissatisfaction not only with the quantity of scientists emerging into society, but also with the quality. Increasingly, countries are recognizing a need for some concentration of resources in order to satisfy the needs of the economy. Also recognized was a de facto concentration of resources in the form of elite schools serving wealthy urban communities of literate and discerning parents that could charge high school fees and also attract funding from local industries that employed the parents.

The challenge is to replicate these successful schools in more economically deprived areas. South Africa is in the process of establishing 'Dinaledi Schools' and Namibia 'Comprehensive Schools' with just this aim. Other countries such as Ghana and Senegal have already set off down this road with mixed success. The very considerable congruence between the requirements of the public and private sectors around this issue offers interesting possibilities for co-operation, and this is developed further in Section 4.

6. See, for example, L. de Feiter et al., *Towards More Effective Science Teacher Development in Southern Africa*, Amsterdam, VU University Press, 1995; and F. Caillods and K. Lewin, *Science Education and Development*, Paris, UNESCO / IIEP, 1996.

Table 8. The main elements of a school system showing four levels of development (de Feiter)

	1. Teacher background 2. Teacher professionalism 3. Teacher reaction to innovation	*1. Curriculum interpretation 2. Teaching techniques*	*School organization: 1. Textbooks and other materials 2. Supervision/support*	*1. Possible change 2. Teacher development 3. School development*
1. Unskilled	1. Questionable mastery of subject content; no or little professional training. 2. Teachers often isolated and poorly motivated. 3. Ignorance, confusion and non-application.	1. Narrow subject content, emphasis basics; low standards; high wastage accepted. 2. Recitation, rote learning and memorization; students copy from blackboard; no individualization.	1. One textbook per class used by teacher; near total absence of instructional materials. 2. Sporadic supervision, focused on administrative control and compliance with regulations.	1. Simplify structure and provide structured teachers' guides, textbooks, and minimal instructional materials. 2. Train teachers in subject matter and a few basic teaching techniques; help teachers perceive need for improvement. 3. Strengthen school supervision and support; bring order to the school.
2. Mechanical	1. Moderate subject mastery; limited professional training. 2. Incidental contact with colleagues through in-service training; some interest in professional improvement but easily discouraged. 3. Uncertain about use; focused on personal mastery; dilution of innovation to adapt personal, professional capacity and motivation.	1. Highly structured, emphasis on no or little curriculum differentiation; standards imposed by examinations; repetition accepted as a means to uniformity. 2. Memorization; slavish adherence to curriculum, short-term activities and objectives; rigid application of one instructional technique.	1. One textbook per student in core subjects. 2 Supervision occasional; focused on compliance; in-service training infrequent - focused on dissemination of structured programmes: emphasizes standardized application of curriculum and materials.	1. Broaden curriculum: teachers' guides and textbooks set standards enforced by exams. 2. Increase subject mastery training; introduce a few simple techniques to make teaching more effective and varied; increase confidence of teachers through training and school-level support. 3. Train headmasters in development of basics of school curriculum, staff, and organization; stimulate department building and teacher co-operation in and between schools.
3. *Routine*	1. Adequate subject mastery; adequate training. 2. Incidental contact with colleagues; interested in improving student performance if adequate incentives are provided. 3. Sceptical about immediate effects; willing and able to make honest effort; will try to adapt innovation for ease of classroom management and standardized application.	1. Curriculum goals begin to broaden, but syllabus still heavily dominated by examination; some curriculum differentiation and tracking of students present; in principle, opportunities for adaptation and experimentation exist; little attention to career guidance of students; concern is prevention of failure. 2. Memorization still dominant, but increasing attempts to introduce 'learning by doing'; medium-term planning using textbooks and materials in a more goal-oriented way; limited variation.	1. Additional texts available; deviations and selective use of available text begin to occur; supply of materials adequate; small school library. 2. Supervision more frequent and less oriented toward compliance; in-service training more frequent - emphasizes the application of innovations in classroom teaching; role of principal as source of knowledge becomes more important.	1. Teaching more focused on understanding; some diversity and flexibility can be introduced to the curriculum; objectives can be broadened to include attention to process skills, science and society issues and career guidance. 2. Introduce more complex forms of teaching; promote professional exchange between teachers and career development of teachers. 3. Train headmasters as educational leaders; stimulate collaborative work-culture in schools and school/subject development plans.
4. Professional	1. Good subject mastery; well-trained. 2. Frequent contact with colleagues: reads of professional publications; interested in improving student performance. 3. Needs of students is central focus; willing to try and test alternative approaches, confident about own ability to master adapt innovation to fit needs of particular group of students.	1. Meaning and understanding stressed wider curriculum; allowance for variety content and methods; considerable attention to the role of the school for students' future life. 2. Self-generated habits of learning: reflective practice; ability to investigate new ideas; longer-term instructional planning allows teacher to adapt use of materials and curriculum sequence to student needs; individualized or multi-group-discussion instruction.	1. Broad availability of textbooks, supplementary reading materials and reference books; well-stocked school library; variety of instructional materials. 2. The principal becomes source of pedagogical support; external support and assistance are available on a contingent basis; training emphasizes the development of professional skills, allowing teacher to select appropriate instructional approach in each situation.	1. Innovation becomes permanent feature. 2. Teachers can be encouraged to behave and perceive themselves as professionals; offer diverse staff development opportunities. 3. Make schools more independent in their operation and responsive to the needs of society.

Attracting and retaining the teachers

All countries reported the attraction and retention of good science and mathematics teachers as a serious issue. It is not a complex issue, however; in the market economies of the region, qualified science teachers could command higher salaries elsewhere. Somewhat surprisingly, none of the solutions common elsewhere had been adopted. Longer salary scales and associated incentives for extra responsibility and rarer qualifications were only common in private schools which were rather more sensitive to the market.

Changing salary structures need not necessarily increase the overall salary bill in the long term. Younger teachers in the new structure would be paid less and more experienced ones, who meet the competency targets and/or take on additional responsibilities, would be paid more. Two further points should be noted; in most countries in the region, the PTRs, particularly the secondary PTRs, are low, indicating scope for efficiency improvements. Secondly, a pay structure that leads to science teachers remaining longer in the system would reduce expensive training and support costs.

Equity and access

The question of access and equity in the region has been much researched and discussed. Two manifestations of inequity were raised at the workshop; the rural–urban divide and the male–female divide. Several general observations emerge from national statistics:

The historical imbalance in secondary enrolment which favoured males over females is disappearing as primary enrolments move towards 100 per cent.
An imbalance in enrolment and performance in optional senior secondary science and mathematics programmes which favours males, remain.
A rural urban imbalance exists in all countries in senior secondary enrolment, science and mathematics enrolment and performance and gender differences are greater in rural areas.
The historical imbalances, based on ethnicity, in science enrolment and performance in science and mathematics, in South Africa and Namibia, have not changed significantly (although in neither country are such statistics collected directly) and the emerging generation of scientists in these countries still comes overwhelmingly from the previously advantaged groups.
Access to tertiary science, technology and mathematics programmes (including teacher education programmes overwhelmingly favours males.
Available EMIS information does not give an accurate picture on equity and access issues, particularly on urban–rural differences, and on rectifying historic ethnic imbalances.

It was recognized at the workshop that an emerging equity and access issue is that of children orphaned by HIV/AIDS, particularly those who will have duties as heads of households prematurely thrust upon them. The needs of this group must be clearly understood by schools and adjustments made accordingly.[7]

7. For further research and discussion see, for example, V. Reddy, 'Relevance and the Promotion of Equity', in P. Naidoo and M. Savage (eds.) *African Science and Technology Education into the New Millennium: Policy, Practice and Priorities*, Cape Town, Juta, 1998.

The box 'Promoting Equity and Access', summarizes a number of steps that have been suggested.

Assessment Assessment issues were raised as key determinants of classroom activities in the prevailing assessment-driven culture. The importance of ensuring that assessment techniques match the objectives of the curricula has already been discussed. This section raises a number of emerging issues of difficulty in reconciling assessment and curricular objectives.

Table 9 shows some of the trends in science education on the continent.

Promoting equity and access

More information is required from EMIS services on the issue, particularly on urban-rural disparities in access and performance and on the extent to which historical imbalances are being rectified. Few research programmes have addressed the issue.

More female science teachers are needed. The University of Dar es Salaam has in place a successful programme that addresses this issue.

Centres of excellence in science, when they are set up, should have redressing inequities as a specific target which should be monitored. Boarding facilities should be available specifically for learners from rural areas. Such schools should have quotas for girls.

More pilot programmes should be established that attract good teaching staff to educationally deprived areas, after the pattern of 'desert allowances' that once operated in Botswana. These programmes should be very specifically targeted, perhaps at individual schools.

Scholarship programmes, with private sector support, should target disadvantaged learners.

Learner and teacher materials should meet standards established to ensure gender neutrality and contain sufficient local material to be relevant to learners from rural areas. The move from externally produced textbooks to those produced by local authors is noted but so is the absence of clear standards governing their content. Author and illustrator training programmes are important.

Improved career advice is important, particularly for girls, to guide them in subject choice. The importance of advocacy by schools, in local communities, is often raised in this context.

Teacher education programmes should include strong components and activities that make (male) teachers aware of how certain practices, particularly in practical science, may disadvantage girls.

All school programmes should be planned in such a way that the emerging needs of orphans are well understood and catered for.

An increased focus on basic literacy and numeracy programmes in early primary grades is a well established mechanism for assisting the most educationally disadvantaged, who have had little benefit of such matters from their background. One consequence of this is the need for related basic literacy and numeracy programmes at teacher education institutions taught in a model manner.

Integrating the sciences has been shown to be a useful way of increasing female participation in sciences.

Summative and formative assessment

A clear distinction was made at the workshop between the requirements of formative assessment (which serves mainly to monitor progress and is an essential component of repertoire of a reflective teacher) and (summative assessment which measures student achievement). Particular difficulties arise when, inevitably, assessment instruments have to serve both functions, as often happens when a continuous assessment mark is a component of the final grade.

Table 9 Trends in assessment of science subjects

Changes in assessment methods	Most countries have made attempts to introduce continuous formative assessment as part of the examination. Changing the norm-referenced examination practices into a wholly criterion-referenced assessment system is currently being considered in a number of countries, but only three countries have turned it into a policy priority yet (Botswana, Namibia, South Africa). Namibia and South Africa have also introduced new ways of grading
Continuous assessment challenges	More guidelines and support should be provided to teachers on how to assess students and what skills to assess. This support could include training, manuals, guides, integration of assessment guidelines in teaching materials. Novel assessment techniques such as the use of portfolios should be piloted
Assessment of practical skills	Most countries report that summative practical examinations are conducted, particularly those taking science subjects at Grade 12 or 13 Namibia uses an 'Alternative to Practical' written Grade 12 paper which tests a variety of practical skills amenable to such testing. They report that it is not answered well by learners who have done little practical work. A number of countries report that they are developing systems of assessing practical skills by continuous assessment

Continuous assessment issues

While desirable, particularly as a means of assessing practical skills and also as a means of spreading the burden of assessment over more activities, the introduction of continuous assessment techniques was reported as fraught with difficulties related to standards. Countries that used this as a component of the summative assessment tended to moderate the mark heavily or reduce it to a relatively insignificant component of the total.

Only two countries (Botswana and Namibia) reported attempts to assess practical skills using continuous assessment strategies. In both cases, considerable problems are being encountered (see box 'Addressing Assessment Issues').

Differentiation in assessment systems

The importance of matching assessment techniques to curriculum ideals has been emphasised. As the principle of 'one size fits all' is being abandoned in the curriculum, so assessment techniques are changing either (or both) to a system that involves multiple papers that test at different levels or to a system of several different examination levels (see box, 'Addressing Assessment Issues').

Addressing assessment issues

Assessment strategies must be coherent with curriculum objectives and both must be coherent with the teaching and learning materials used.

Assessment strategies must be realistic. This means that most of the teachers who have the task of implementing them must be capable of being trained to do so within a reasonable time and budget.

Assessment strategies must support rather than drive teaching.

Teachers should be familiar with assessment strategies and should be trained in both pre- and in-service programmes to produce valid test items that match the philosophy and item types of the public examinations.

Banks of good tested question types should be developed and made available regionally electronically.

Continuous assessment of practical skills is not easy. Pilot programmes are needed to identify the main issues and the results disseminated regionally.

As a means of promoting more practical work, a few simple practical activities can be made compulsory. Clear specifications for such lessons can be developed together with clear continuous assessment techniques. These should be capable of being conducted with simple equipment in ordinary rooms.
Details of such activities should be shared regionally.

The unfortunately named 'alternative to practical' type of paper has proven validity for testing many scientific skills. It could be adopted more widely. It should be renamed to indicate that it is a means of testing competencies developed through practical activities. Question types can be shared electronically. If necessary they can be integrated into ordinary question papers.

Differentiated assessment techniques must be developed to match the differentiated curricula being developed for grades 11 and 12. These typically might take the form of differentiated question papers linked to core and extension syllabus sections. Simple question papers based on the core curriculum will be used to differentiate between the lower grades and higher order questions based on both core and extended syllabus components serve to differentiate between the higher grades. The traditional concept of a final grade based on a 'total' mark in all papers must be seen as no longer appropriate.

An alternative and simpler form of differentiation is the development of differentiated examination levels based on different syllabus components such as the South African Matriculation system and the Namibian HIGCSE/IGCSE system. These two systems are not mutually exclusive.

4. Facilitating effective partnerships between the public and private sectors

Introduction

The coincidence of purpose between what the public and private sectors wished to see from the education system was a striking feature of the workshop. It was clear, however, that because of a lack of co-operation and co-ordination of the efforts made by both sectors, the resources put into the system by all were not being used optimally. This section focuses on mechanisms by which co-operation between the two sectors can be achieved and looks at a number of possible results of such an enhanced co-operation in the light of existing good practice.

Co-operation between the public and private sectors to support education systems is currently largely incidental. It does not happen as part of a clear vision or plan, and it happens in small self-contained programmes that do not often impact on the system in general, or on each other. Co-operation has arisen from a coincidence of (usually) local needs, and has been driven locally. None of this implies, however, that where it happens, the co-operative ventures have been ineffective; indeed they have been the source of many significant developments and achievements, particularly in supporting science and technology.

The challenge is to replicate individual and isolated achievements effectively nationwide and to add value to the achievements through a clarification of the roles of all involved and by bringing them under the umbrella of a common, agreed strategy.

Existing school management models

Many countries in Africa are currently experiencing rapid growth in community-driven private secondary schools. This is demand-driven and is happening because the state is unable to meet the demand. This enforced change from a fully supply-driven educational model to a system driven mainly by demand is significant, and requires a major change in the view taken by the public sector of its role in the process. This development is, however, not new. The states in the region long ago began to enter into partnerships with the private sector and NGOs to offer educational provision in response to need.

Table 10. School management models

Origin	*Government schools*	*Community schools*	*Faith organization schools*	*Company schools*	*Private schools*	*Devolved government schools*
Context	Response to community need	Communities wishing to complement perceived inadequacies in public education.	Usually originally mission schools established before the arrival of public education	Established to meet the education needs of company (or farm) employees. Often part of the employment package. Often established jointly by several companies. Charge fees to non-company parents sending their children there	Private not-for-profit (usually) organizations serving the private education market. This market may vary from poor parents in an area where state provision is unsatisfactory to the international diplomatic and corporate community	Public sector schools with management functions, including financial management fully devolved to the local level and run by local communities. School boards take responsibility for raising funds from all sectors, including a government grant
Capital costs	Owned and managed by governments, often with an appointed school board with varying degrees of responsibility, answerable to the community	Community funds or small fees sometimes with matching governments grants	Faith organization, perhaps with some public subsidies	School foundation fund set up by the companies	School foundation	School board using funds from government and private sector
Salaries	Government. Some schools with large funds may pay additional teachers from them	Community or government. Sometimes a matching grant arrangement	Usually now government but some may be paid by the faith organization and some posts may be filled by unsalaried volunteers from the organization from overseas	School foundation fund set up by the companies	School foundation	School board using funds from government and private sector
Recurrent costs other than salaries	Government with contributions form a school fund to which parents contribute and which can be enhanced though fundraising events and donations from the private sector	Community and school fund	Faith organization and school fund	School foundation fund set up by the companies and school fund	School foundation, parents, fundraising functions	School board using funds from government and private sector, parents, fundraising functions
STE Equipment	Usually mainly from the school fund. Some from government	Community and school fund	Faith organization and school fund	School foundation fund set up by the companies and school fund	School foundation, parents, fundraising functions, donations in kind	School board using funds from government and private sector, parents, fundraising functions, donations in kind

These partnerships, however, were not seen characteristically as part of a deliberate plan, but rather as one-off acts that were individual solutions to individual problems.

Table 10 lists a number of different kinds of secondary school that are managed with a varying degree of private participation. Many of these models are common throughout the region. Significantly, most have been established as part of a process in which once fully private institutions have been partly absorbed into the state system, rather than as a result of any deliberate policy to establish them. Almost all involve public–private partnerships in which the non-government partner is either a charitable NGO, such as a religious institution, a company, or a community establishing its own private school in response to local demand.

Table 10 shows that a wide spectrum of public–private partnerships is already in place in the region. What is not generally in place, however, is a policy and related strategies to promote or exploit any benefits that arise from the co-operation. In general, the partnership schools are seen as the exceptions to the rule, accommodated for historical rather than educational reasons. There are few examples of policies aimed at the deliberate establishment, if any, of such jointly managed institutions.

Neither is there much evidence yet, despite the political rhetoric, of the wide adoption of a necessary prerequisite to increased private participation, the localisation of school management within the government system. The last column in Table 10 describes this type of school, which is now common elsewhere in the world. It is a public school, managed by its own board, to which all management functions have been fully devolved, giving it the freedom to operate with characteristics of a private school while offering a service to the public sector. Significantly, one country in the region, South Africa has established this structure, as a deliberate political act, as a means of empowering previously disempowered communities. The South African Schools Act (see box 'Enabling Legislation') presents an interesting model for other countries.

Devolved management leads to a more empowered staff, which is good for morale, and they are better able to encourage the participation of parents in the functions of the school. A key consequence of this is that they are better able to generate funding for school activities (such as buying their own science and technology materials) from parents, through fund-raising events, and from the private sector - particularly if key people in the sector are also parents.

Existing promising partnerships

Effective change is generally evolutionary not revolutionary. Evolutionary change allows for pilot programmes; it allows us to learn from mistakes before they affect the whole system. It allows for new partnerships to be established in a small way before they are everywhere applied. It allows for a multiplicity of solutions to a particular problem to be developed and tested.

Enabling legislation: The South African Schools Act

It is likely that, in most countries in the region, existing legislation will not have provision for any kind of joint-venture school that goes beyond subsidies or grants one way or the other. The South African Schools Act of 1996 was designed specifically with the aim of devolving power and responsibility to the school level; it provides an example under which a wide spectrum of cost-sharing partnerships can be accommodated.

Under the Act, school boards and principals answering to them are allowed an unprecedented freedom to control their own affairs. Issues such as general management and purchasing, codes of conduct, language policy, the times of the school day and even the curriculum are all, within agreed guidelines, devolved to locally elected school boards. In effect, the legislation gives public schools almost as much freedom to operate as private schools, except that the number of teachers paid out of public funds is not in the hands of the school. The school may, of course, employ additional teachers on its own account.

The school board can determine, after appropriate parental consultation, the size of any school fee to be levied and this is compulsory for all parents unless they can demonstrate their inability to pay. This contrasts with the usual school fund legislation.

The Act allows schools almost unlimited freedom to develop cost-sharing strategies, both with parents and with private sector companies.

The Schools Act, as amended in 2002, also allows for a continuous spectrum of private provision which is entitled, as of right, to government subsidies the size of which is related to the per capita cost of provision in the area and also to the fees that are levied in relation to this cost. The purpose of this is to allow private schools to serve poorer communities, or poor elements in a wealthy community, on a cost-sharing basis with government.

A number of partnerships were cited at the workshop as promising examples that have evolved and been refined and that could be developed and replicated elsewhere. It was also realised that many more examples clearly existed, but that no central record existed of them, or of any studies of how effective they may be.

The following boxes describe several categories of effective partnerships that already exist in the region in various forms, study bursaries, partnerships in course planning and development, funds established to support the needs of a specific industry, and tripartite arrangements linking a funding agency and a private education service provider and educational institutions.

Study bursaries

Many companies throughout the region have, for a long time, offered study bursaries, particularly for students wishing to study science and engineering subjects at a tertiary level (see box, 'Study Bursaries').

An element that tended to be missing in the many bursary award schemes was any detailed attempt to link the schemes to national, as opposed to company, needs. Indeed, there did not seem to be reliable mechanisms in place generally in the region either to predict future needs or to maintain an overall inventory of the number and nature of bursaries awarded each year.

Study bursaries

Generally, the award is linked to the professional need of the company, although it often does not bind the student to the company other than through a gentleman's agreement.

There are good examples of industry-wide schemes awarded through representative bodies such as the Chambers of Mines.

They are particularly common for students wishing to study science and engineering subjects at a tertiary level, but many companies offer general support for employees wishing to further their education in ways that would benefit the company.

Many of the bursary award schemes are not tied to national further education institutions and indeed it was evident that many of these award schemes greatly benefited South African academic institutions.

The existence of schemes that were not tied to a country, but to the region, reinforced a call for regional centres of excellence that are equitably spread throughout all the SADC countries. The UNEVOC model, whereby a regional centre in vocational training has been recognized in Botswana, is a possible example. The need for specialist centres is particularly significant where technical staff with a very specific specialization are required – but not in large numbers. In such cases (such as, perhaps, marine geology) it makes particular sense to concentrate the training expertise in one centre. Such a concentration of scarce resources is a time-honoured way of raising standards and is reflected in SADC protocols. Planning is necessary to avoid uneven concentrations of such centres.

Education support funds

The Petrofund in Namibia (see box, 'The Petrofund, Namibia') provided an interesting prototype of a cross-industry fund established to support all aspects of education related to the needs of the industry.

The workshop identified a number of areas where such a fund, operating across the whole region could assist with a number of important regional activities.

Tripartite public–private partnerships

A particularly common structure for effective partnerships is the tripartite arrangement which links a funding agency with a private education service provider and a public education institution or system. There are many examples of this worldwide. This model links a funding agency, which is likely to be a company wanting to publicize its brand name in a socially responsible manner, with a private education service provider to offer a service to educational institutions. Many examples can already be found in the region (see box 'Tripartite Public–Private partnerships').

The Petrofund, Namibia

The Petrofund was set up in Namibia to receive funds from petroleum exploration companies in response to the granting of off-shore exploration rights. The fund provides a good working example of how industry-wide funds can serve science and technology education needs and the advantages that such funds often have over individual company funds.

There are a number of advantages that an industry-wide fund has over individual company initiatives:

It can offer full-time professional administration of the educational funds that can monitor how the funding is being used, relieving individual companies of this burden.
Through a steering committee on which all stakeholders are represented it can ensure that it addresses real national needs.
Through its full-time centralized secretariat it can draw up criteria that have to be met by individuals and institutions applying for assistance.
By combining funds from a number of companies and investing the capital wisely, it can ensure that its activities are sustainable.
It is able to support a wide range of activities that can be linked in a way that adds value to individual donations, such as the simultaneous provision of science or mathematics equipment and the training in its use.

Tripartite public–private partnerships

A particularly common structure for effective partnerships is the tripartite arrangement that links a funding agency with a private education service provider and a public education institution or system. This structure allows for a clear contractual arrangement between the two private institutions, and avoids the issue of having to provide money to a (government) institution that may have no mechanism to receive it.

Many different examples can be found within the region ranging from the small-scale involving one local company and one school to national schemes. Some cases involve just one funding agency while others may involve a large number.

A particular variant worth noting is that in which the service provider is a professional fund-raiser. In such cases, the fund-raiser may be responsible for bringing together several services into one package, such as the combination of a venue, transport, materials and trainers, for some professional development work.

The table below gives a number of examples of tripartite arrangements drawn from experience in the region.

Some examples of tripartite partnerships

Funding agency	*Education service provider*	*Educational institution(s)*	*Activity*
A number of private sector companies	Schoolnet.na	Schools	Provision of networks of refurbished computers that offer schools internet access
Private sector company social responsibility fund	Publisher	Schools	The funding company purchases the print-run of a minority subject textbook that could not otherwise be economically produced. It then sells the book back to the government as needed
Private sector company social responsibility fund, or industry fund	Private sector or NGO training agencies, or professional fundraiser	Teachers	Provision of in-service training
Donors, international and local	Private sector or NGO programme implementing agencies	Ministries of education	Capacity and institutional development programmes

Programme design, planning and oversight

The creation of steering committees to oversee the work of a particular educational programme is becoming commonplace, particularly if the programme involves several institutions across the sector. Such a committee, drawing on the expertise of all interested parties, is not only a useful source of advice, tapping experience that would otherwise remain untapped. but it provides an added legitimacy to the work of the programme. It is an effective mechanism for ensuring that all institutions involved in a programme feel they have some ownership of it. It also, of course, spreads the responsibility for any failure.

While such committees are common in areas where a programme needs the co-operation of a wide variety of outside bodies to function effectively, they remain less common in areas, such as school curriculum development or teacher training programmes, which are traditionally seen as the sole responsibility for the professionals involved. Even the curricula of vocational training programmes, have, in the past, often been decided by the ministries involved, with only limited input from outside. In this sector, however, where close co-operation is very much in the interests of all, the participation of industry is becoming the norm.

The vocational sector offers models of how such ventures might be managed. The key challenge here is to generate mechanisms which will maximize the benefits of private sector involvement while minimizing their involvement in the implementation bureaucracy. Some suggestions are listed in the box, 'Private Sector Involvement in Development, Planning, Teaching and Monitoring Procedures'.

Private sector involvement in development, planning, teaching and monitoring procedures

Involving the private sector in course planning and monitoring activities

Many steering committee members are very busy people. It is inappropriate to involve them in the detail of the programme. The following guidelines are based mainly on the experience of the Polytechnic of Namibia:

- Limit the frequency of meetings and manage them strictly to maximize their productivity.
- Ensure that accurate notes of the meeting are taken, circulated in a timely manner and agreed at the subsequent meeting.
- Steering committees should not be involved with details. Their views on broad aims, structures, procedures and outcomes should be obtained and these can be then translated into details, such as curriculum statements, by professional staff. The final product – the curriculum or the programme details – can then be brought to the committee for approval.
- The views of the committee must be taken seriously. It follows that the membership of any committee is crucial; they must be experts that know the subject and can play a serious role.
- The committee will be involved in progress monitoring and quality assurance. It follows that time-tables and quality assurance indicators must be agreed and all progress reporting to the committee by the various elements of the programme should be done systematically against these indicators.
- It is desirable that the membership of a committee should represent collectively all institutions that have an interest in its activity. This is particularly important in areas such as training where industrial or school placements are an integral part of the programme. This involvement allows for a feedback mechanism from the field to the committee.

Involving the private sector in teaching activities

While the routine matters of teaching are usually best left to trained professionals there are a number of educational experiences at all levels that can only be provided by outside experts. This issue is covered from another perspective below under Science Centres, but some important contributions that can be made to the teaching process are listed below:

- Special courses or lectures at tertiary level by acknowledged experts. These are common worldwide in almost all fields of technical endeavour.
- Career advice by company or industry career officers.
- Special lessons directed mainly at girl students by female role-models from industry.
- Lessons illustrating local industrial activities, possibly linked to visits. These have been used effectively as part of teacher education and support programmes in the region. A significant role in promoting these might be played by the private sector by simply providing the transport for teachers and learners.
- Involvement of the private sector in tertiary course moderation.
- Industries often now have staff well-trained in catalysing discussion around HIV issues. The fact that they are from outside and do not meet the learners every day in other contexts often enables them to address learner's concerns more readily than the teacher can. This is particularly so if the trained staff are relatively young. This is a service often provided to schools that serve the staff of a particular industry, and could be more widely used.

Advocacy; the public understanding of science

Science-based companies have a long record in the region of funding activities that promote not only science but the image of science (and their image with it). Science competitions, road shows, and latterly science centres have always been well-supported (see box, 'The Public Promotion of Science and Technology').

One of the science centres in South Africa has developed a mobile exhibition to visit 'hub' schools in an area. Other schools then send classes to the 'hub' during its stay there of one or two weeks. This option is, however, expensive, and it seems never to have been done in the region in a comprehensive and sustainable manner.

The public promotion of science and technology

The public promotion of science and technology is an area where there is a long history of partnerships between the public and the private sectors, not least perhaps because of the opportunity it offers the private sector of taking part in an activity that is promotional as well as educational.

Two manifestations of this co-operation that are well known in the region are the promotion of activities such as 'Young Scientist' and the more recent example of the sponsorship of science centres. Apart from the Botswana Technology Centre and the emerging centre in Malawi, all the science centres that have so far opened their doors are in South Africa.

'Young Scientist' competitions

'Young Scientist', and related competitions such as 'Mathematics Olympiads' and 'Conservo' are typically run by teacher organizations. These vary in their strength from province to province and, as might be expected, tend to be strongest where there is sound leadership from teacher education institutions, and where there is a relatively high density of good professional teachers who are secure in their ability and knowledge in how to help their learners compete. A challenge for organizers and funders alike is how to promote their activities successfully in the more rural, scientifically deprived, areas.

Science centres

The Southern African Association of Science and Technology Centres (www.saastec.co.za) is part of a world movement to establish hands on science centres of all kinds. So far there are some thirty three centres in South Africa, some based on the activities of existing science based institutions, others established from scratch to serve their local

communities. Most have had, and continue to have, industrial backing and this is sometimes reflected in their name (MTNScienCentre) . All depend crucially on enthusiastic and able scientists to develop and manage them.

Multipurpose science centres

The only science centre in the region outside South Africa is the Botswana Technology Centre. Like some of the science centres in South Africa, this serves a dual role; that of publicizing science and technology and also conducting serious research and development activities. Given that many of the other countries in the region have recognized the need for local innovation centres and are building the necessary legislative and institutional structures to establish them, in co-operation with their private sectors, the Botswana model could serve as a useful blueprint.

There are numerous other functions that a science centre might embrace; one is as a 'One Stop Shop' for career teachers needing advice to pass on to their learners; another would be as a source of information for science teachers about the details of local industrial processes. A third could be as a centre for information on industrial bursaries available. In many of these functions, the centre would not only be serving the public, but also, importantly, its donors.

Other award schemes

The workshop recognized the value of incentives to promote science, mathematics and technology in schools, particularly scientifically disadvantaged schools. Incentives might take the form of awards to the best performing students, particularly girl students in national examinations. Awards to best performing schools are also important. If this is done on a regional basis, some of the better rural schools would also benefit with competition removed.

Road shows

Science centres are static. This means that many parts of the region, particularly the most deprived anyway, are unable to benefit from them. Putting the exhibits in a bus is a way of overcoming this and it has been used before in the region as a means of encouraging girls into science careers. Following the Commonwealth Prime Ministers Conference, a mobile COMMQUEST exhibition toured South Africa taking science to the people.

Conceptual issues that govern the role of partners

Education, in southern Africa, is traditionally viewed as a public good to be provided (largely) free by the state. States have, by and large, been in full charge of what has been supplied, for whom and to what level. Involvement of parents and of the private sector has, in general, been minimal, incidental, and usually limited to a service role. The whole process has been supply-driven from the top down by ministries acting, to a greater or lesser extent, on behalf of the people. Seldom have the people been consulted on the detailed nature of the good that is to be provided, other than in a very general manner at election times. Neither has the main consumer, the private sector, been extensively consulted or involved.

It is argued[8] that if the resources that the private sector can bring to the education are to be fully exploited there must begin a significant shift away from this supply-driven model towards a demand-driven model where a new enabling environment must be formed in which functions and responsibilities of all involved in education provision are redefined. This will entail a paradigm shift in the role of the state some aspects of which are captured in Table 11.

8. This document attempts an outline summary of topic that has been much researched and developed as educational systems have experimented with innovative financing and delivery initiatives worldwide. More information can be found at websites such as the World Bank Edinvest pages, http://www.ifc.org/edinvest/index.htm

Table 11. Changing the education model

Supply-driven model	*Demand-driven model*
State controlled	State monitored
Education seen as a public good to be provided by the state	Education seen as a service to be purchased by the consumer
State provides the service	Any organization can provide the service
What is provided is determined by the state acting on behalf of electors	What is provided is determined by the provider within guidelines laid down by the state
Quality determined by the state	Minimum quality controlled by the state through a licensing and inspection system
Cost determined by the state	Cost determined by the market with state maintaining a watching brief
What happens in the school is determined by the state	What happens in the school is determined by the consumers with state oversight
State controls access and equity usually through the provision of schools in the right places	State monitors access and equity through the provision of vouchers, subsidies or similar 'safety net' processes
State provides all (or most of the) funding	Funding shared by state, the private sector, parents, charities, etc.
State owns the schools	Schools owned privately, corporately, by a board of governors or by the state
State employs the teachers on civil service contracts	Teachers employed by schools on individually negotiated contracts
Ministry or regional authority is accountable for performance	School board is accountable for performance
Governments ignore or minimize contacts with private sector education suppliers	Governments develop a pro-active policy of engagement and co-operation with private sector education suppliers

Public–private partnerships in the past have usually evolved as ad hoc initiatives promoted by individual schools or companies; the kind of initiative that has been described thus far in this chapter. Typically, they have lacked institutional structures and they have not been part of any national policy. Indeed, they have tended to thrive in spite of, rather than because of, national education policies and structures.

The paradigm shift in the perception of the role of governments, from provider to purchaser of education provision, opens up possibilities of many more mechanisms for mobilizing private support for education to the benefit of both partners. Under the new paradigm, new processes, of a kind listed in Table 12, can become institutionalised in ways that give added value on top of what either partner can achieve individually. We are beginning to see evidence of this happening within the region with the advent of, for example, self-funding training programmes, especially distance programmes, at public universities and polytechnics, and private training companies operating in many areas, particularly ICT, but also, now, in teacher education.

In technical and vocational education, we are beginning to see an increased private involvement at all levels – so much so, that the old relationship in which training was organized and promoted by government with private sector support is effectively being reversed, and training will be organized and promoted by the private sector with government support.

Table 12. Summary some of the new relationships that are emerging

Private financing and ownership	*Private management*	*Private provision*	*Private support or ownership*
Funding from user fees	Management contract	Contacting out services	Joint venture
Funds from capital market	Service contract	Public procurement from private providers: – goods – services	Ownership of institution Support for, or ownership of elements of the institution
Industry financing	Concession or franchise	Private provision from private funding	Donor funding
NGO funding Charitable funds			Support in kind

However, so far in the region there has been little official movement to mobilize resources for secondary education through public–private partnerships. The private and public education systems still remain almost wholly separate and largely ignore each other. The outsourcing of educational services at this level tends to be limited to the provision of peripherals such as buildings, books, equipment and furniture and seldom, if ever, to the core functions of education such as learning, teaching, training, management or support services.

Where government secondary schools are able to mobilize support from the private sector it is frequently viewed with some unease by governments, fearful perhaps of a loss of control. Typically such developments have resulted from a strong leadership in the school, with strong and organized parental backing. In such situations, the school may be the most powerful educational institution in the region, and tensions in the relationship with regional education offices are not uncommon.

In the context of science and technology, it is important to note that, in the region (with the exception of Botswana), almost all the recurrent funding of science and technology subjects, and the greater part of the (non-donor) capital funding, is supported from local private sources, usually from school funds raised partly from parents but also from local industry that is served by the school. It is therefore hardly surprising to note that there is frequently a strong correlation between science results and the size of the school fund. It follows from this that, for science subjects, national provision remains far from equitable and there is an urgent need to replicate nationally the success of some schools in mobilizing such resources.

Taking it forward: models for partnerships in education

There is currently much debate continent-wide on mechanisms for improving access to and efficiency of, secondary education, and on mechanisms for ensuring that the products of education match the needs of the labour market, now and in the future. But, at a time when an increased role is being proposed for the private sector in education, there seems to be a lack of sufficient debate on exactly how that might happen. On this, the workshop had a number of suggestions which are discussed below.

Information gathering

A major issue identified at the workshop was a deficiency of information on the nature, extent and effectiveness of all the partnership activities. It was therefore proposed that both ministries of education and chambers of business conduct surveys among their schools and members to investigate the extent and effectiveness of existing practices (see box, 'Information Gathering by Ministries of Education and Chambers of Business').

A co-operation agenda

Public–private partnership in the past has been largely incidental, often in response to specific local, company or national needs. It has been characterized by a lack of co-ordination and a general failure to add value to the co-operation by integrating it at any level into national policies, and strategies.

At an early opportunity, a co-operation agenda should be agreed through meetings at the level of ministers and chamber chairpersons and executives. This would agree on the principles and general direction for future co-operation and identify initial areas where pilot programmes might be developed.

Ideas proposed for such an agenda are shown in the box, 'A Co-operation Agenda'.

Joint venture schools

An interesting, but hitherto somewhat underdeveloped feature of the southern African educational landscape, are the private sector schools established by companies, mainly for the children of their employees. They have been established, for the most part, because existing provision was either absent or was not felt to be of sufficient quality to attract the kind of employees required by the company. The alternative would have been to build into employment packages an element for private boarding education elsewhere, and for many reasons this was deemed undesirable, particularly at primary level.

Because major company activities also attract commercial and financial sector supporting businesses who find themselves with similar difficulties, these schools have often been joint ventures between several companies and have sometimes also served, in addition, fee-paying parents who may not be attached to the foundation businesses. Crucially, also, governments may be contributing to the financing of such schools, using an ad hoc agreed formula, as part of a package that provides education to the children of workers in the non-formal sector that establishes itself around such towns and performs a much needed service.

The majority of such schools in the region serve the primary phase only, as there is a long tradition of private secondary schools with boarding facilities throughout the region (some of which may have been established in company towns as private ventures precisely to tap this market). However, this situation is frequently regarded as an unsatisfactory alternative to good quality secondary education nearby. This generates a hitherto unexploited convergence of interests on the part of the private sector employer and governments seeking to expand secondary access and also to increase both the quality and quantity of scientific expertise coming from the schools.

Information gathering by ministries of education and chambers of business

Information gathering by chambers of business

All the countries at the workshop indicated very considerable private support for education. This support covers a wide spectrum of activities some of which are listed below. All countries reported, however, a deficiency of information on the nature, extent and effectiveness of all the activities.

It was recommended that at an early opportunity, the regional chambers of business should undertake surveys amongst their membership to determine the extent, effectiveness and value of their contribution to the national education programme.

The survey might gather information on:

- Details of actual activities undertaken in the last five years.
- The perceived effectiveness of the support programmes, particularly if they involved innovative promising practices that could beneficially be more widely replicated.
- The motives of the private sector for providing the support.
- Suggestions and proposals for making the support more effective.
- Suggestions and proposals on the main focus of any nationwide activities.
- The main impediments that companies find in ensuring that their support has the intended impact.
- Mechanisms, particularly fiscal ones, by which governments can encourage and guide such activities.

Information gathering by ministries of education

Because much of the private sector support comes not only from private companies but also from individuals and NGOs, governments should undertake a related survey among their educational institutions to determine the extent of private sector input, its nature, and how effective it has been.

The list below summarizes some of the main ways that were identified, in which the private sector currently supports public education.

- Local support, mainly from parents, for schools through school funds.
- Local support for public schools in a community from major enterprises around which the community has grown.
- Local or private sector support for professional development activities.
- Support by government for private schools that serve the public by providing free access for some, or all members of the community around the school. The school may be managed by a private company or an NGO such as the church. The support typically might take the form of direct, or indirect, payment of teacher salaries.
- Funds established by the private sector to support specific educational developments.
- One-off donations by the private sector of capital items such as buildings and laboratories.
- Tripartite support by private sector companies of other private sector companies or NGOs providing a variety of educational service to the public sector.
- Joint ventures between the public and private sectors to meet the educational needs of a community.
- Private sector support for the establishment and management of vocational training institutions, particularly those serving a specific industry.
- Donations in kind.
- Student bursaries.
- Systemic involvement of the private sector in curriculum and course design.
- Private sector involvement in the establishment of national qualifications and in the certification processes.
- Private sector funded rewards for academic excellence and for excellence in science teaching.

A co-operation agenda

Public–private partnership in the past has been largely incidental, often in response to specific local, company or national needs. It has been characterized by a lack of co-ordination and a general failure to add value to the co-operation by integrating it at any level into national policies and strategies.

At an early opportunity, a co-operation agenda should be agreed through meetings at the level of ministers and chamber chairpersons and executives. This would agree on the principles and general direction for future co-operation and identify initial areas where pilot programmes might be developed.

This agenda might commit both parties to, *inter alia*, the following programmes:

- A critical examination of the roles, achievements and shortcomings of the activities of both parties in satisfying national educational needs.
- A re-examination of the fundamental roles of both sectors in the provision of educational services.
- The identification and prioritization of future areas of co-operation, based on mutually agreed needs and on an analysis of effective past practice.
- An examination of the legislative framework that constrains co-operative activities with a view to appropriate amendments where necessary.
- The establishment of joint-venture pilot activities which can guide the development of future co-operation.
- The establishment of administrative guidelines for future co-operative ventures.

Such a convergence of interests offers potential opportunities for the provision of an educational service that meets the demands of the private sector for the quality of provision that will allow them to attract the level of staff they need, and also for the public sector to address some of their traditional interests such as rectifying inequities in the provision of, and access to, high quality education, particularly science and technology education.

Some of the issues around joint venture schools are examined further in the box 'Joint Venture Schools' and a specific example, the centre of excellence, is considered below.

Joint venture schools

The establishment of joint venture schools will involve extensive debate on changes in the traditional roles of both parties. Critical issues in this debate are: (a) the school management and administrative structures; (b) joint financing; (c) accountability and reward of the teaching staff; (d) the role of the ministry; (e) admission rules and requirements and (f) the legislative environment.

Management and accountability
The private sector is able to bring to education, systems of management and control that in general are more streamlined and transparent than exist in the public sector. Private management of the school will enable it to take advantage of these structures and also put in place systems that demand greater accountability on the teaching staff and at the same time match reward with commitment and achievement.

The role of the ministry
The ministry role in the venture will not be that of a provider, but will be that of a procurer of the services, and also of quality monitoring through its inspectorate. Its involvement in the learner selection process will allow it to address issues of equity and access. There may be additional roles for it as a provider of services such as training and support, although this model could allow the private sector to compete for these services. Ministry services could be built into the joint venture agreement or supplied on a commercial basis, Conversely, the school itself may, either as part of the agreement, or on a commercial basis, act as a focus for public sector teacher support and professional development in its area, or indeed, in the country.

The legislative environment
National schools legislation may not be in place that permits joint-venture schools to function effectively. Changes may be needed. The South African Schools Act of 1998 (discussed above) is an interesting ex-ample of such enabling legislation that allows any school to form itself into not-for-profit company with extensive freedom of action largely uncoupled from the control of the ministry.

Centres of excellence

Attempts to create a scientific elite without creating an elitist education system inevitably results in compromise. The scientific elite is a prerequisite for industrial development which benefits all, but creating it in an environment characterized by inadequate provision, inevitably involves a system of elite schools. Many African countries are walking this tightrope with varying degrees of success. South Africa, with its proposed 'Dinaledi schools' and Namibia with its similar number (in proportion) of proposed 'comprehensive schools' are on a similar track. The challenge is to create schools that will produce well-qualified science and technology students but that do not favour any particular class or ethnic group and, furthermore, do not, in the process, use significant funds that would otherwise be directed at the majority.

Given that the goals of these public schools often coincide with the goals of private sector schools established to serve the needs of employees of particular companies (see above), a strong case exists for combining the two enterprises, with joint funding, and creating a more efficient and larger school (more than 800 learners) than would have been the case if each enterprise was undertaken separately. Additionally, the greater flexibility of private management is better able to attract and retain good teachers and enhanced private funding will enable classes to be smaller and better use to be made of novel learning technologies such as ICTs.

Centres of excellence should be open to all, or all within a defined region, who can satisfy agreed entry criteria, but they need not necessarily be free to all. Additional issues such as these are considered in the box below. A particularly important additional function of centres of excellence is to act as a professional development hub. The school staff should also offer training and support to teachers in other schools nearby and this should be a recognized element of their contract (as in Zimbabwe) and in their appraisal.

Centres of excellence

This coincidence of interests in the two sectors offers scope for innovative pilot initiatives. The list below indicates some of the characteristics that might form part of such an initiative:

- Established by the private sponsor, or as a joint venture.
- Public sector funding will be at the normal per capita level for secondary schools.
- Education is free (except for optional school fees) to all learners.
- Boarding facilities.
- Free or subsidized boarding to learners from afar, or scholarships for those unable to meet boarding costs.
- Private sponsor guaranteed an agreed number of places.
- Private sponsor funding used to provide additional facilities and add quality.
- Not-for-profit company with private sector school management practices, including the hiring, paying and terms and conditions of teachers.
- Own, and be responsible for, its own buildings.
- Managed by a school board on which no institution has a majority.
- A voucher (or similar) system might be instituted by which parents of appropriately qualified learners that could benefit from the kind of education offered by such schools can be given vouchers to exchange for such an education at any such school. The size of the voucher could reflect the means of the parents.
- Ministry responsible for quality monitoring.
- School can offer training or support services to other schools, either as part of its constitution or on a commercial basis, perhaps subsidized by the sponsor.

Cultivating effective partnerships

Increased private involvement in the public education systems is a worldwide phenomenon. Effective partnerships require a degree of mutual understanding of interests and an acceptance that conventional roles can and must be changed. The summary checklist below outlines a number of pre-requisites that should be in place before effective public–private partnerships can grow:

- An extensive analysis of existing good practice in public–private co-operation in education, particularly an analysis of the principal impediments
- An increased involvement of the private sector, as the consumer, in fundamental issues such as educational quality, educational management, and the nature of the curriculum
- A desire on both sides to try and test innovative models for co-operation, and, on the side of government to modify existing structures that impede the functioning of such models
- A culture change in national educational bureaucracies and planning processes from one in which the private sector is largely ignored and excluded to one of partnership with new clearly defined roles and responsibilities for each sector
- A major shift towards decentralisation and localising of decision making and financing to school level
- A shift from the norm of government provision of services to a norm of government supervised private provision of services.

The direct interests of the private sector do not wholly coincide with the responsibilities of ministries, however. This dialogue, therefore, must not lose sight of those matters that are traditionally a major concern of government. These may be summarized as:

- Concerns relating to the legal and regulatory frameworks that govern public educational systems.
- Concerns relating to equitable access for all, not just those well served by wealthy schools.
- Concerns of accountability such as the issue of school and teacher performance (and reward).
- Concerns relating to the trust between parent and school that relate to the role of the school '*in loco parentis*'.
- Concerns relating to the responsibility of the educational system for handing down a culture.
- Concerns relating to the role of the school in the community, particularly in the more remote areas.

The need for pilot examples

Educational changes always prove more difficult than anticipated and a significant catalyst in the process is the existence of pilot examples, set up champions of the change process. Such examples are usually promoted by people who have the vision to see them through and meet problems head on. Their experience in solving the problems is invaluable.

5. Networks and forums for science and technology

Science education associations

Science teacher associations, both national and international, are a vital element in the pursuit of excellence in science and technology; they raise morale, they are at the helm of curriculum development, they drive training, they maintain interest. Sadly, throughout the continent, with one exception, they have, by and large been ephemeral and ultimately ineffectual.

Studies[9] of the rise and fall of science teacher associations reveal much about why, after a while, they tend to fail. Some reasons for the ephemeral nature of such associations are listed below.

- The large distances between secondary schools in most of the region make transport to meetings difficult.
- The rise and fall of champions. Often the welfare of a network relies crucially on one person and the network fails when they leave for greener pastures.
- Associations often enjoy periods of success during periods of political change, such as during post-independence euphoria. When the impetus melts away, so does the network.
- Associations need money to maintain their activities which justify their existence. If the money runs out, the association withers.
- Some successful associations have been killed by foreign generosity. Their activities have attracted the attention of donors who have injected funds to make them more effective in the short term. This leads to a dependency and the association dies when the funding stops.
- Management failure has led to the collapse of some associations.
- During the 1960s and 1970s continent-wide associations enjoyed considerable success and influence. Examples were the Science

9. Some reflections on this issue can be found in E.A. Yoloye, 'Historical Perspectives and their Relevance to Present and Future Practice', in P. Naidoo and M. Savage, *African Science and Technology Education into the New Millennium: Practice, Policy and Priorities*, Cape Town, Juta, 1998.

Education Programme for Africa (SEPA) and, most notably, the African Primary Science Programme (APSP). They arose through worldwide networks but were largely indigenous in nature. They vanished with the advent in the 1980s of large donor-funded in-country programmes that took over their operational territory.

The Science Teachers Association of Nigeria, STAN*

Founded in 1957, STAN currently has about 3,000 paid-up members and membership has increased almost every year since it was founded. Its principal activities are listed below.

- Publication of textbooks and teacher materials.
- Teacher education. It is the main in-service training and support institution in the country.
- Curriculum development. It has been primarily responsible for all the major curriculum development programmes in Nigeria over the last thirty years.
- Advice to the federal and state governments on all aspects of science education.
- Organization of national and international conferences.
- Sponsorship and execution of research.

A number of characteristics have contributed to its success:

- It is good at publicizing its activities throughout the profession.
- It has a strong leadership based at universities as well as schools.
- It provides a needed service to its members.
- It has a regular income from royalties; most of the science textbooks used by the 4–5 million learners have been produced by STAN.
- It is able to obtain sponsorship for its members to attend international meetings and undertake overseas fellowships.
- It organizes awards for excellence in the profession, usually commercially sponsored.
- It is an organization in a large country and hence membership is large

It is interesting to note that, unlike science teacher associations in the southern African region, its prime interest is in the professional development of its members and in the related areas of curriculum and materials development. It has not focused directly on the learner through science fairs, competitions, etc.

- http://www.stanonline.org

The one exception that has run counter to the trend and has remained influential over a long period is STAN, the Science Teacher Association of Nigeria. The reasons for its resilience are significant; it has, in its function and choice of activities, trodden a path that has been rather different from its less successful counterparts. This is discussed further in the box.[10]

Research associations

One organization exists in the region to promote research into science, mathematics and technology education, it is the Southern African Association for Research in Mathematics, Science and Technology Education *(SAARMSTE)*.

10. The success of STAN has been much studied. A recent study is by F. Adesoji et al., *Contribution of a Teachers Organization to SMICT Education, the Case of Science Teachers Association of Nigeria (STAN)*, 2003, to be published as part of the SEIA Science thematic study.

SAARMSTE is an active organization with chapters in every country in the region. It organizes an international research conference in the region in January each year (2004 – Cape Town; 2005 – Windhoek). It publishes an annual peer-reviewed journal of international repute, the *African Journal of Research into Mathematics, Science and Technology Education.*

National and regional science educator forums

Science teacher associations seem to vary in popularity and performance. They are not easy to establish, requiring a legal entity and constitution. A simpler variant is the educator forum that links educators electronically. These are embryonic in some of the countries but will gain ground as teachers increasingly turn to electronic means of communication. They can be linked to electronically available resources (see below); and they can readily be linked to similar forums elsewhere.

SMILE–Africa. Science and Mathematics Innovations and Leadership in Education – Africa. This is an informal list group of mainly science and mathematics education staff at a number of Southern and East African universities linked with the Vrije Universiteit, Amsterdam.[11]

SANTEC. The Southern African Network for Educational Technology and e-Learning. This is a recently established network linking a number of e-learning institutions and people with an interest in electronic learning.[12]

INGOSTE is the International Network of Government Officers in Science and Technology Education launched by UNESCO's Science and Technology Education Section in 2001 in order to establish closer links with and among the ministries of education of UNESCO's Member States in matters pertaining specifically to science and technology education. Each country has one member who has a mandate to ensure that the activities of the forum are disseminated.

The members of INGOSTE representing the workshop countries are given below:

Angola	None	–
Botswana	Marianne Nganunu	mnganunu@gov.bw
Lesotho	Benedict Khoboli	sesp@Lescoff.co.za
Malawi	Chrissie Mwiyeriwa	psnrm@sdnp.org
Namibia	Alfred van Kent	avankent@mhevtst.gov.na
South Africa	Michael Kahn	mkahn@hsrc.ac.za
Swaziland	Celumusa Dlamini	–
Zimbabwe	Tracy C. Mudzi	–

11. The email address is: smile-africa@yahoogroups.com It is a moderated group and the moderator who can add names to the list is Rob Merkus at p.merkus@dienst.vu.nl

12. Membership is free and can be applied for on the site: www.santecnetwork.org

Electronic networks and resources

The region is entering a period where quite a number of teacher networks and online resources are emerging. In general, these are currently driven not by demand but by a top-down, supply-led process. Most are commercially driven but others are being established by individuals or individual institutions. They will be subject to the normal evolutionary processes that we have seen elsewhere; some will disappear, some will join forces, and eventually some will emerge with an effective regional role.

In such an arena, it may not be sensible to start any new networks or online resource sites, but rather to develop and enhance promising existing ones and to link existing resource sites.

The challenge therefore is for a substantial regional institution, already developing its own online science teacher resource database and its own science teacher forum, to take on the role of a regional centre.

Science teacher online resources

Few online resources currently exist in the region to support science teachers.

Commercial sites

Embryonic learner support sites are evolving but are clearly currently driven by the technology and not by the teaching profession. The best developed is probably www.learn.co.za which is mainly for learners. It betrays a number of characteristics of the genre of sites that are driven by IT specialists rather than teachers; it contains a number of errors and misconceptions, portrays a physical science teacher as a white male in a white coat, and science as something that happens in a special laboratory.

Other local sites that have been identified are:

http://www.easymaths.org

http://www.mweb.co.za/hub/learning/default.asp

http://www.teacherspet.co.za/educatorsresources.htm

http://www.sabceducation.co.za http://www.schooltool.org/ (this one is financed by the Shuttleworth Foundation and is developing 'Open Source' software for school management).

Commonwealth of Learning STAMP materials

The Commonwealth of Learning (COL) recently co-ordinated the development of a useful and innovative package of generic teacher support materials for upper primary and lower secondary mathematics and science in the SADC region. These were written by teachers in the region and professionally edited. They can be found on the (COL) knowledge base, http://colfinder.org/odl/index.jsp by entering STAMP (Science, Technology and Mathematics for Primary) in the search engine.

Namibian teacher materials

Teacher materials for Namibian science and mathematics programmes can be found on the website of the Mastep programme (Mathematics and Science Teacher Extension Programme), www.mastep.org.na. Most of the materials were produced for the INSTANT (IN-service Training and Assistance for Namibian Teachers) project in the early 1990s

Appendix A: Workshop details

Overview The regional workshop on Partnerships for Relevant Science and Technology Education in Southern Africa was held at the Safari Hotel Conference Centre, Windhoek, Namibia, from 28 to 30 July 2003. Participants representing commerce and industry and the education sector from Angola, Botswana, Lesotho, Malawi, Namibia, Swaziland, South Africa and Zimbabwe took part. A list of participants is given at the end of this Appendix.

The workshop was divided into two broad components, one being an analysis of the main issues of science and technology education in the region, and the second, to examine a number of mechanisms for addressing the issues, particularly, mechanisms that bring the private sector on board. The workshop programme is shown below.

The deliberations opened with joint presentations from the public and private sectors from each country on the main issues in science and technology education.

These presentations were followed by workshop sessions in which the first two themes of the workshop, the demands on science and technology education and the capacity of existing resources to meet the demands were debated simultaneously. The participants, individually and collectively, first identified a number of critical themes and these were then further analysed in small breakaway groups.

The second phase of the meeting, through two simultaneous workshop sessions, looked at ways in which partnerships between the public and private sectors, and partnerships between countries in the region, could help meet some of the challenges identified in the first phase.

PROGRAMME

Regional Workshop on Partnerships for Relevant Science and Technology Education in Southern Africa, Windhoek, Namibia
28 – 30 July 2003

Day 1 **28 July 2003**

Official Opening

09.00 – 09.05	Welcome and Introductory Remarks *A van Kent, Director, Research, Science and Technology Directorate, Ministry of Higher Education, Training and Employment Creation*
09.05 – 09.10	Overview of UNESCO's Activities in Science and Technology Education and Purpose of the Workshop. *Claudia Harvey, Director and UNESCO Representative*
09.10 - 09.20	Science and Technology in the Private Sector *Esther Hoveka, Namibia Chamber of Commerce and Industry, Private Sector Representative*
09.20 – 09.30	Official Opening *Hon. Mr John Mutorwa, Minister of Basic Education, Sport and Culture*
09.30 -09.45	TEA BREAK
09.45 -10.00	Presentation of UNESCO's work on STE: Main actions and activities ongoing and planned. *Ms Julia Heiss, UNESCO, Paris*
10.00 – 10.10	Country presentations: challenges and existing promising practices on STE
13.00 – 14.00	LUNCH BREAK
14.00 – 17.00	Working groups around two themes: *Theme I.* Does STE meet the needs of the economy? What major demands on STE are not being currently adequately met? Constraints from the perspective of: • Private sector. • NGOs. • Governments. What are the main issues: • Quantity and quality. • Relevance of the curriculum. • Level of understanding. • Flexibility and usefulness of those emerging from the system, etc. *Theme II.* What are existing promising practices at the policy and implementation levels? What useful regional resources exist and what might be developed? • Networks: networking between practitioners, producers and consumers, countries.

- Web-based resources.
- Involvement of private sector in curriculum design.
- Public understanding of science.
- Regional co-operation in STE regional centres of excellence.
- Regional training centres.
- Regional research co-operation, etc.

Day 2 **29 July 2003**

08.00 – 09.00 Report back from working groups on themes I and II

09.00 – 09-30 Discussion

09.30 – 09.45 TEA BREAK

09.45 – 13.00 Working groups around two themes

Theme III. What should public–private partnerships to support STE look like? What examples are there of existing good practice? What should be the purpose of such partnerships and what can the partners gain from them?
- Bursaries.
- Material support.
- Training support.
- Support in ICT.
- Direct involvement of private sector in pre-vocational and science programmes.

Theme IV. What kinds of regional partnerships are possible and useful?
- Examples of promising practice.
- Exchange programmes.
- Fund sharing.
- Knowledge and resource sharing.
- Regional training centres.
- Regional centres of excellence, etc.

13.00 – 14.00 LUNCH BREAK

14.00 – 15.00 Report back from working groups on themes III and IV
15.00 – 16.00 Discussion

15.00 – 15.15 TEA BREAK

15.15 – 17.00 Group discussions: developing concrete strategy and proposals for partnerships

Day 3 **30 July 2003**

08.00 – 09.00 ..... Report back on themes I, II, III and IV (Facilitator)
09.00 – 10.00 ..... Conclusions and recommendations: the way forward (Facilitator)
10.00 – 11.00 ..... Closure

Director General, Namibia Broadcasting Corporation

INFORMATION CIRCULAR SENT TO PARTICIPANTS

Regional Workshop on Partnerships for Relevant Science and Technology Education in Southern Africa, Windhoek, Namibia 28 – 30 July 2003

Organized by: UNESCO Windhoek Cluster Office and Section for Science and Technology Education, UNESCO, Paris

Background

Progress and development, in the modern world, is inevitably linked to advances in Science and Technology. The spectacular advances made in this domain, notably in the past two centuries, have not only opened up an array of new fields and domains at the macro and micro levels (e.g. space exploration, biotechnology, nano-technologies, etc.), but have also allowed for a much wider exploration in existing/known fields thanks to the development, for instance, of electronics, ICTs, ultra sonic and laser technologies, etc.

These developments have had definite repercussions on the world of work as they have systematically opened up a range of new opportunities for youth entering the employment market. What is more, it is now generally acknowledged that advances in science and technology will continue to spiral generating newer fields in the coming decades accompanied by newer job opportunities for the young.

A sound base in STE is thus a definite help for young people who will be faced with an increasingly quick-changing world of work dominated by scientific and technological progress where flexibility in adapting to continuously evolving demand will be their surest bet for successful survival.

This workshop is a regional response to the fact that we live in a world increasingly shaped by science and technology and that in consequence, without an appropriate science and technology education, people will not be able to find their way in our fast-moving, interconnected and globalized world. At the World Conference on Science and Technology (Budapest, 1999) it was clearly stressed that there is an urgent need to renew expand and diversify basic science education for all with emphasis on scientific and technological knowledge and skills needed to participate in society.

Indeed, it is well acknowledged that science and technology education not only contribute to the formation of open and critical thinking, but also to the general improvement of people's ability to meet the challenges of modern society. STE is critical for promoting sustainable development and improving the capacity of people to address environment and development issues. It has the potential to inculcate environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and to foster public participation in decision-making. These principals are applicable to all regions of the Worlds including Africa; thus there is an urgent need to reshape STE in this context with special emphasis on the most critical needs and expectations of the region in this domain.

A continuous and vivid dialogue between education provider and potential employers is therefore imperative in order to adapt STE contents to the demands of the world of work, as well as to match demand and supply for science education at policy level. Such a dialogue should further remind the employing sector of its responsibility and their direct interest in investing and supporting an education that responds to their needs of skilled labour in the field of S&T.

S&T education in Africa is confronted with several problems that can be gathered around the following keywords: participation, equity, exclusion, quality and relevance, resources and expertise, leading to issues such as, for example, STE, gender and poverty reduction).

Science and technology is regarded as a critical ingredient to the speedy socio-economic development on the African continent and a critical driving force in the implementation of strategies in science and technology. NEPAD has identified science and technology development and the creation of regional centres of excellence in Africa amongst its priority areas.

The SADC group, comprising heads of science and technology from the SADC member states, have been meeting to discuss ways and means to develop a common strategy for science and technology. One of the main concerns was to establish administrative frameworks to co-ordinate and enhance collaboration amongst various science and technology players, both at the national and regional level. This exercise resulted in the creation of a science and technology unit under the Department of Trade in the SADC system.

At the local level a number of member states, including Namibia, has developed national policies on science and technology. A number of issues that are common in these policies are emerging such as: demystifying science and technology; encouraging the enhancement of targeted funding to the sector; building science and technology institutional and human capacity; and protecting and promoting indigenous knowledge systems.

One of the main challenges facing the region is the different levels of the development of science and technology systems. It is expected that with improved collaboration, networking and exchanges of experiences and expertise, member states would be able to benefit from each other and integrate science and technology in their development strategies.

Partnership building is one of the means of addressing problems related to STE. The importance of partnership building and its role is increasing in the field of education in general, and particularly in science and technology.

Among the advantages of partnerships is their potential to mobilize greater amounts, and a wider variety of skills and resources than can be achieved by acting alone. They can further address problems in a more integrated, multidisciplinary and comprehensive manner, and eliminate unnecessary duplication of cost and effort, which is especially important in STE where there are shortages of financial resources or relevant skills. They can help traditional adversaries, or organizations, which have had little cause to interact in the past, to broaden their perspectives and to respect each other's needs and capabilities. Partners can also facilitate the flow of information and promote technology transfer.

Despite an increasing acceptance of their value, the awareness and experience of cross-sector partnerships remains limited. While there is growing anecdotal evidence of their benefits, there is still much to learn on how to structure, manage and replicate them. There is a need for greater analysis of the characteristics that make partnerships successful, and the situations in which they are effective. There is also a need to understand their limitations and obstacles.

Through this workshop we would like to explore the possibilities – potential, but also limitations of partnerships as a means to support UNESCO's effort – in assisting Member States to improve and strengthen the relevance of their STE policies, curricula, contents, teaching/learning methods and materials and training programmes from an integrated/interdisciplinary and gender-sensitive perspective; encourage new initiatives and trigger political actions and supports within the context of education for all at the formal and non-formal levels, and at the same time, develop capacities for using science and technology as tools for preventing or solving daily life problems

Objectives

- To exchange experiences and ideas on partnership in STE at the national, regional and sub-regional level.
- To discuss trends, challenges and constrains of STE in the region.
- To develop concrete proposals for innovative pilot projects in partnership with the private sector, NGOs, governments and UNESCO.
- To familiarize participants with UNESCO's programmes and activities in STE, in particular networking activities.
- To present and discuss the draft 'Guidelines for Policy Making in Secondary School Science and Technology Education'.
- To encourage possible student exchange activities both within and between countries as well as internships with private companies.
- To promote regional networking activities and partnerships between the participating stakeholders.

Expected outcomes

- The workshop should have explored the potential and possibilities of partnerships to contribute to the enhancement and relevance of STE in the Region.
- An increased understanding of the demands the private sector and industries put on a STE which enables students to confront the challenges of the world of work.
- Identified barriers between formal, non-formal education and the working life and possible strategies to overcome those.
- Developed concrete proposals for partnerships between the private sector, NGOs and governments in promoting quality STE as well as to develop pilot projects for possible extra budgetary funding to be implemented in partnership with UNESCO.

Background documentation

- Draft 'Guidelines for Policy-Making in Secondary School Science and Technology Education'
- 'Science for the 21st Century - A New Commitment Declaration on Science and the Use of Scientific Knowledge'
- 'Science, Technology and Mathematics Education for Human Development - Review and Framework for Action' (Goa, February 2001)
- 'UNESCO and NEPAD: From Vision to Action' (Ouagadougou, 5–7 March 2003)
- Participants are requested to bring to the workshop their curriculum/policies on S&T education in their respective companies/countries.

Participants

Each country sent three participants: a member of the INGOSTE network, a representative of the private sector and an NGO representative.

OPENING ADDRESSES

Dr C. Harvey, UNESCO country representative
Address points

UNESCO continues to encourage and assist Member States in developing effective programmes in line with EFA goals in the formal and non-formal sectors, focusing on gender-sensitive, socio-culturally and environmentally relevant policies, curricula, training, teaching/learning materials, methods and good practices. It is our intention to work more closely and directly with the private sector and non-governmental organs concerned as a way of encouraging faster implementation and running of programmes.

Following are the areas in which UNESCO is supporting Science and Technology Education:

- UNESCO's education and natural sciences sectors launched an intersectoral programme to focus on strengthening Member States' capacities in policy-making, planning and monitoring of national programmes at school and higher education levels. The programme is to be pursued and extended in the present biennium.
- Some science sector programmes and initiatives on education and capacity-building in science and technology with focus on higher education include:

Policy-making and science education

- Follow-up to the World Conference on Science in Budapest, and the Science Agenda, which recommends adoption of national policies that imply consistent long term support to science and technology.

- UNESCO's role: standard-setting in the field of science and technology policies with the overall goal to build expertise for managing science and technology for development.

Capacity-building in the basic engineering sciences and on engineering science and technology
Emphasis on:

- Activities aimed at capacity-building in technologies related to sustainable development.
- Sound management of the environment, with the goal of enhancing the acquisition of expertise in technologies and their transfer to developing countries, favouring those related to cleaner production, water supply, urban transportation and the management of risks.

Some science sector programmes and initiatives on education and capacity-building in science and technology with focus on higher education include:

Capacity-building in mathematics, physics and chemistry

- To provide advanced research training for scientists, especially young scientists as well as university and pre-university staff in chemistry, mathematics and physical science.

Capacity-building in eco-system science and management

- At an institutional and individual level through global knowledge network, linking research and training institutions.
- The network focuses on issues of human use of natural resources in an ecosystem context with a special attention on women's role in ecological stewardship and the role of local and indigenous knowledge.

Capacity-building in biological sciences and biotechnology

- Through support to international centres and national institutions hosting UNESCO chairs.

Water education and capacity-building for sustainable development

- Education and science sectors to work together to strengthen links between water-related UNESCO Chairs and work on institutional strengthening of water educational capacities worldwide.
- The International Water Education Institute in The Hague launched POWER, Partnership for Water Education and Research, and a network of institutions.

Other initiatives include:

UNISPA: University–Industry–Science Partnership

- Launched by UNESCO in 1993 to promote university participation in the industrialization process of the Third World countries and in countries in transition.
- UNESCO raises issue of technology-led industrialization in developing countries from the standpoint of 'How can Academia Contribute?'
- UNESCO believes that university–industry co-operation can be a valuable contribution to the industrialization of developing countries.
- UNESCO's effort is aimed at encouraging local universities to be more involved in the process of industrialization and at attracting industry towards co-operation with universities and research institutes.

ANSTI, the African Network of Scientific and Technological Institutions

- An organ of co-operation that embraces African institutions engaged in university level training and research in the fields of science and technology.
- Founded in January 1980, through the financial support of the United Nations Development Programme (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and Germany.
- To date it has ninety-eight member institutions in thirty-three countries in sub-Saharan Africa.
- Support to S&T education is a public–private initiative, and the importance of the private sector cannot be overemphasized.
- Participation of the private sector in this and other activities helps strengthen links, and contributes to general capacity-building.
- As a tool to access emerging technologies and ideas that can boost businesses and stimulate the economy, S&T education should be given priority and requires more support as a measure towards achieving poverty reduction.
- Economic indicators given in 'The United Nations in Namibia' (2003), sourced from the Bank of Namibia and the Central Bureau of Statistics, indicate that 75.9 per cent of households in Namibia live under the poverty line, in spite of the country being in the middle-income group. This is an indication that there is a high income disparity,
- In relation to the above, the challenge is to meet the MDG to eradicate extreme poverty and hunger, to which Namibia has committed itself to reduce the incidence of poverty, the poverty gap ratio and the share of the poorest quintile in national consumption.
- The UNESCO Windhoek Cluster Office is also committed to supporting initiatives in poverty reduction and has addressed it as a cross-cutting theme for all its actions identified as priority areas by and for the Cluster Member States. Some of these include promoting sustainability through water management and

renewable energy, girls' education in science, and the use of technology through multimedia centres and diverse media.

Ms Esther Hoveka, Representative of the Namibia private sector

Science and technology and the private sector
Hon. Ministers, representatives of the diplomatic corps, representatives of the media, distinguished participants, ladies and gentlemen:

My presentation this morning, is not a research paper, nor is it an expert opinion on science and technology education. Rather it is a view on the role of science and technology in private sector growth and development in Namibia in the context of global developments and trends and the development challenges we face as a nation.

The role and enterprise of science and technology is changing rapidly in economic development. Science and technology is recognized as being vital to injecting the vibrancy required to create a robust economy, for a number of reasons.

The continued success of industry is dependent on new management, processes, products and specialized knowledge. Industry and markets are thus much more dependent on science and technology as well as research and development.

The pace of technological innovation has accelerated, and competition stiffened. This requires the capability to quickly absorb new technologies and products, which means a change in the skills composition and type of competencies of the labour force in industries.

The globalization of industries and markets require economies to shift their strategic focus on niche markets that need specialized knowledge and skills.

Scientific discoveries increasingly take place in the context of application, and continuous improvement in becoming more important than revolutionary breakthroughs.

At the same time, the lower costs and increased rate of information flows globally whilst presenting the opportunity for industries to draw from the global knowledge base. However it also means that they have to be able to use this knowledge to stay competitive in the global arena. This makes it more important to have a labour force that is both skilled and innovative, adaptable and flexible.

It is within the context of these trends in role of science and technology in economic growth that Namibia must meet its socio-economic development challenges. It is worth noting that perhaps more than most countries in the region, Namibians are more dependent on wage labour for their livelihoods. A labour force with the right skills and competencies is thus critical to creating employment opportunities (and access to them) which is central to reducing poverty in Namibia. In this context, education and training in science and technology will be crucial in enabling the growth and development of industry in Namibia that will support the achievement of our national goals and objectives as articulated in Vision 2030.

At present, there is a critical shortage of engineers and technicians in the Namibian labour force. These are the skills that will enable the economy to grow when you consider Namibia's comparative advantage in mining, fisheries, energy, agriculture and manufacturing, and value-adding industries. At the same time, our education system produces a large number of dropouts lacking the basic mathematics and science skills to enable them to further their education in scientific and technological fields. Most of these learners will eventually be condemned to the ranks of the unemployed. Even for those who do have the basic skills, the number of places available for them to pursue further education in these fields is very limited. There is no question in my mind that Namibia needs to drastically increase learners' access to science and technology education through improving the learners' pre-requisite skills to be able to pursue further education opportunities in these fields and the number of such opportunities available within the limits of the resources available. The key to success will lie in mobilizing and co-ordinating resources, efficiently managing resources, focusing performance in delivery and quality of outputs. It is in these areas that I believe the private sector can play a role.

The private sector has played an important role in education in general in Namibia.

Donations
Largely in meeting their social responsibility, companies have given bursaries, supported educational infrastructure development and sponsored specific activities such as school competitions promoting science and technology. There is no data available to quantify the level of the private sector contribution in this area. However, there is an opportunity to co-ordinate and target these resources for science and technology education. In this regard the private sector should set up guidelines to ensure that contributions meet with national priorities and a channel for facilitating such contributions. In addition the private sector could get more involved in defining the desired outputs of their contributions, and require: (a) greater accountability, and certain standards of minimum educational achievement from institutions where they make these donations; and (b) the government may also consider incentives for companies to contribute to the development of science and technology infrastructure.

Partnerships
Curriculum development: the private sector could work with educators to develop curricula that reflect private-sector technology, standards and practice;

Partnerships between the private sectors to set up specialized academies for particular industries; these should be closely linked to the industry to allow learners to be exposed to the industry environment. To encourage this, the government could establish a matching grant fund for such initiatives where the government matches the private-sector contribution

Participation in delivery of science and technology education
The active participation of the business sector could potentially have the greatest impact of the expansion of opportunities, improving cost effectiveness of educational delivery, as well as improving the quality of education in Namibia. It has been observed that the profit motive has been highly effective in stimulating growth, access, quality improvements and investment in other sectors of the economy. There is no reason why we cannot expect the effect in the education sector. As examples, I will focus on three areas.

Remedial education
Upgrading skills of out-of-school learners in mathematics and science; the private sector could participate in providing programmes to specifically upgrade learners' mathematics and science skills

Secondary schools
There are very few truly private educational institutions in Namibia. With a framework specifically conducive to promoting private provision of science and technology, the private sector could contribute effectively to the expansion of science and technology education, as well as improving its quality.

Technical and vocational education – computer training
The experience in other countries shows us that the private sector can be an effective provider of technical and vocational education. In India for example the private sector has been very effective. In Namibia we are seeing the private sector participating particularly in the IT field. This could be expanded to other areas.

Tertiary science and technology education and training
With regard to tertiary S&T training and education specifically, we see the following challenges:

- A limited number of places available for learners to pursue tertiary education.
- A narrow variety of types of programmes and organizational models in higher education constraining the tertiary educational system from meeting the variety of needs amongst learners.
- Limited linkages between the tertiary education system and industry constraining the relevance of tertiary education to the needs of the private sector.
- Insufficient channels for the private sector to make its contribution to tertiary education. In this regard, there are opportunities to: (a) enhance the private contribution to the public tertiary education sector by enabling TEIs to leverage private sector financial, experience and expertise in a more systematic, tangible and measurable manner; and (b) foster linkages between TEIs, industry and business, and to ensure win/win outcomes from such linkages.

I believe that one effective way of encouraging such partnerships would be if the government could establish a fund that would match the private sector contribution in such partnership activities, provided that the activities meet criteria established to ensure that the public tertiary education sector is relevant and responsive to the needs of the economy, and that these partnership arrangements contribute to the goals and objectives of Vision 2030.

I believe that there are promising areas such as those I have mentioned in which partnerships between the private and public sectors contribute positively to improving science and technology education. However, there needs to be a shift in the thinking about the roles of the government and the private sector when it comes to education as well as the communities' perceptions about these roles.

The government needs to think about its role more as a facilitator, co-ordinator and regulator, rather than the prime supplier of educational services.

Official opening statement

The Honourable John Mutorwa, Minister of Basic Education, Sport and Culture

1. While warmly welcoming all the participants, especially those from outside the national borders of Namibia, I at the same time also wish to thank the organizers of this workshop, for having brought together public and private sector officials to discuss a very important subject: science and technology education in our sub-region, SADC; and by extension in our continent, Africa.
2. You have organized and planned this workshop with a crystal-clear purpose and intention. After thorough, constructive and evidently successful discussions, you must have achieved a certain set of objectives. Chief among those objectives would certainly be the following:
   - Develop concrete proposals and recommendations on priorities and strategies for UNESCO's programme in Science Technology Education (STE), in the light of the recommendations and priorities of the Windhoek Cluster Consultation, World Conference on Science, the Nepad Strategy, the Goa Experts Conference on Science, Technology, and Mathematics Education (STME).
   - Very importantly, and here I call upon all of you to ensure that, at the end, your workshop will have succeeded in ensuring the promotion of regional networking activities and partnership, between the private sector and the government in and between the participating countries.
3. Article 3 of the Constitutive Act of the African Union (AU), lists the objectives of the organization. There are a total of fourteen objectives. Objective (c) is the following: 'accelerate the political and socio-economic integration of the continent'. For the purposes of this workshop, it is important to know that objective (m) is the following: 'advance the development of the continent by promoting research in 211 fields, in particular, in science and technology'. Ladies and Gentlemen, I do not need to remind you that the development of science and technologies has actually made the world in which we live a global small/big village. The Global Village concept has given rise to fears of competition in the market place. People's choices for products and other services have been broadened substantially by e-commerce activities.
4. I am quite sure that some of you might be asking yourself the following question: What is the connection between globalization (the Global Village) and the education system, especially science education? Permit me to venture a response – an answer. It is only through a sound base of science and technology that many, if not all, our countries on our continent and in our sub-region, could be enabled to meaningfully translate their natural resources and God-given wealth and natural heritage sites, into usable and profitable goods. Our continent and our countries cannot indefinitely continue to be characterized as poor and backward – while, at the same time, it is the natural resources of the same African continent that continue to build many of the developed countries of the world today. During the colonization of the African continent, the African people were politically, culturally, economically and socially enslaved and oppressed. In the letter and spirit of the African Union and its economic development arm, the New Partnership for Africa's Development (NEPAD), the African people (with the support of genuine partners) are saying that the time is now to end the scourge of underdevelopment that afflicts Africa, The resources, including capital, technology and human skills, that are required to launch a global war on poverty and underdevelopment, exist in abundance on the African continent. They are within our reach. What is required to mobilize these resources and to use them properly is bold and imaginative leadership – leadership that is genuinely committed to a sustained human development effort and poverty eradication. Development of science, mathematics, technology education in our schools, countries and continent, is fundamental and a prerequisite in this regard.
5. Above all, it requires a new global partnership, based on shared responsibility, mutual respect and mutual interest. Indeed, one of the proposed actions of the NEPAD's Science and Technology Platforms is 'to work with UNESCO, the Food and Agriculture Organization (FAO) and other international organizations to harness biotechnology, in order to develop Africa's rich biodiversity and indigenous knowledge base, by improving agricultural productivity and developing pharmaceutical products . . . expand geo-science research to enhance the exploitation of the mineral wealth of the African continent' (NEPAD, 2003, p. 49).

6. Among the many questions and issues that you, the workshop participants, are called upon to address, I also beg you not to forget to tackle this question: How can countries with finite resources available to education, increase both the quantity and quality of scientifically and technologically qualified students, to meet the anticipated demand, associated with the industrialization of the economies in our continent and sub-region? This question forms the core of your workshop's main objectives.

Let me now pause here. I shall now allow you to commence with discussing the themes/topics as outlined in your agenda. I wish you successful, constructive and fruitful deliberations. I declare the workshop officially opened.

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Appendix B. List of acronyms

EPSI	Education Policy Support Initiative (of SADC)
GDP	Gross Domestic Product
GER	Gross Enrolment Ratio or Rate; the ratio of the number of enrolled learners in a particular phase to the total number of children in that phase age range. Rates of over 100 per cent indicate enrolment of a number of over-age students. GER1 and GER2 refer to the primary and secondary phases respectively
ICT	Information and Communications Technology
IIEP	International Institute for educational Planning
INGOSTE	The International Network of Government Officers in Science and Technology Education
NAD	Namibian dollars
NER	Net Enrolment Ratio or Rate; the ratio of the number of learners of appropriate age enrolled in a particular phase, to the total number in the phase age range.
PPP	Public–private partnership
PTR	Pupil/teacher ratio
SAARMSTE	Southern African Association for Research in Mathematics, Science and Technology Education
SADC	Southern African Development Community
SANTEC	The Southern African Network for Educational Technology and e-Learning.
SEIA	Secondary Education in Africa (an initiative of the World Bank)
SMICT	Science, Mathematics and ICT
STAN	The Science Teachers Association of Nigeria
STE	Science and Technology Education
TVET	Technical and Vocational Education and Training
TIMSS	Third International Mathematics and Science Study
UNESCO	United Nations Educational, Scientific and Cultural Organization