14. Popularising Science and Technology: The Case of Swaziland

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Introduction

This chapter illustrates the evolution of a country's attempt to establish a science and technology culture that is publicly perceived as a local challenge rather than an imported idea. This is illustrated by school science curriculum reform that promotes strong links with the scientific and technological applications practised in local workplaces. It is hoped that the meaningful and useful school science derived from learning through these concrete local contexts will cultivate scientifically oriented values and abilities among society's youth. Such attributes are regarded as important sources of power which will enable local people to take charge of their country's socio-economic development.

Historical Background

The phrase 'popularising Science and Technology' gained currency in Swaziland as far back as the mid-1970s. It was understood to be about a set of verbal and practical activities aiming to disseminate information that was considered vital for society's socio-economic development. It was expected that such activities would raise the awareness, understanding and interest of the majority of ordinary people about S&T explanations, practices and devices that were increasingly dominating the world. The concern then, as now, was the alarming gap in S&T knowledge and skills between the developed and underdeveloped countries. Hence, there was a need to raise the level of 'scientific understanding' among the peoples of the developing countries. It was expected that this action would accelerate the industrialisation of these countries and so improve the living and working conditions of all their people. This was a global issue initiated by UNESCO. African enthusiasm for the idea of linking national development to popular S&T education for all age groups and social classes was secured during the late 1960s and early 1970s through the declarations of forums such as the Conference of Ministers of African Member States Responsible for the

Application of Science and Technology to Development (UNESCO, 1983).

Swaziland was a relative late-comer to these developments. It became involved after the reports of an African sub-regional conference held in Zambia on 'promoting the public understanding of science and technology' (UNESCO, 1972). At this conference, countries had the opportunity to reflect on what they had done and could do to achieve 'scientific literacy' for their populations. Encouraged by UNESCO, various schemes that had the potential of drawing public attention to S&T practices were proposed in Swaziland by science-oriented non-governmental groups and attempts were made to put some into action. Examples of these activities were the radio talk series on various forms of scientific knowledge that were organised and presented through the voluntary collaboration of the science and science education staff of the local university. Unfortunately these talks fizzled out within a couple of years before their impact on society was assessed or reliable public reaction had been elicited. There was little support from government, either financially or in the form of alternative ideas or future plans for developing a popular S&T culture which could possibly contribute towards the nation's future socio-economic prosperity and avert the danger of being left behind.

Other potentially interesting plans for mass S&T education included the establishment of a Science and Technology Park or a Science Museum in the same way as had occurred in some developed countries. However, the envisaged donor funds for these commercially driven schemes never materialised and the plans fell through. These two examples of short-lived ideas underpin a recurring undesirable theme: that ideas for S&T development often occur as imports into Swaziland to be used mainly for execution, rather than for generating local meanings and strategies for action among the general population. If imported ideas were used for the latter purpose, the implementation stages would possibly be executed with greater facility and on a wider scale because of the perceived relevance of the ideas to local circumstances.

Nonetheless, the importance and benefits of S&T are recognised by individuals and the state. Tangible S&T products, mostly imported into the country, are ubiquitous and constantly sought after or acquired by the majority among all age groups; thus, everyday human needs are served. Unfortunately, the easy access of ready-to-use S&T products brings to the fore some problems typical of many African countries, such as encouraging the following undesirable tendencies:

- a greater reliance on using or trading in available S&T products, and less on creating or producing the desired S&T commodities;
- holding on to static traditional modes of thought and action, such as authoritative instruction, as against scientific or rational modes (Horton, 1967; Tsuma, 1998).

The outcome of such characteristics is related to what Clark and Juma (1991) referred to as 'the vicious circle of technological dependence'; they are inimical to the expressed desire of developing countries to achieve modern industrialisation. Strategies to counteract these forms of mental stagnation, such as those suggested by Wright (1999) and others before him (Hountondji, 1997) on the need for a determined search and documentation of practical indigenous ideas, as well as exogenous ones currently practised in African communities and workplaces are useful starting points. Such invaluable information would then be linked appropriately with the well-documented modern S&T systems of the developed countries in order to evolve powerful sets of endogenous knowledge in a given country. The availability, wide dissemination and effective use of such contextualised S&T knowledge through formal and non-formal education channels could be the right strategy for inculcating a techno-scientific culture among a large mass of the population (Tsuma, 1998). Moreover, the popularisation of local S&T models is likely to increase the chances of improving their effectiveness, quality and status, thereby contributing towards human welfare on a comparable scale with other global S&T creations. In this way, the chances of improving the continent's constantly poor performance in economic, scientific and technical growth and, instead, raising its self-esteem are enormous. These are prime issues and cogent reasons for promoting massive S&T popularisation campaigns in African countries, for these could advance the global goal of the 1960s and 1970s of 'bringing about a scientific temper ... as well as the promotion of creativity and innovation among the population' (Irvine, 1985). This would not only apply to the general population but, most importantly, it would improve regular school science programmes.

The Current Image of School Science

Government policy

Since Swaziland gained its independence in 1968, the government has taken some commendable steps towards popularising science in schools by enacting policies on the curriculum which are in line with development-oriented global trends. Thus, for instance, when the call for 'science for all' was strong in the 1980s, curriculum reform was activated in the country, with international assistance, to ensure that science as a subject was included from the first to the last year of schooling. The goal during that period was to accomplish 'scientific literacy' for individuals and societies; this was a departure from the tenets of the 1960s when the curriculum emphasised the expertise of learners in the content of subject matter. In recent times, the incessant impact of modern technology on Swazi society has generated a clearer recognition of the need to implement school curriculum policies that take account of technology.

Three main strands of action indicating the country's practical concern for the development of scientific and technological literacy can be identified. The first relates to the output of ongoing research and development activities for curriculum renewal during the 1990s. Sets of secondary school science curriculum materials that illustrate a teaching and learning approach based on local technological contexts were developed through two consecutive non-governmental projects. The first, referred to as the Matsapha Lessons, operated during the 1992–95 period (Lubben *et al.*, 1995) and this was followed by the project on Linking School Science with Local Industry and Technology (LISSIT), 1996–99 (Putsoa, 1999). As the positive outcomes of these projects emerged, the Ministry of Education (MOE) issued a science policy document in 1998 which clearly advocated the use of the contextualised teaching and learning approach throughout the 12 years of schooling. A government policy statement relating to a single school subject was unprecedented and was highly regarded by local science educators as a progressive step. However, other areas of the school curriculum have not, as yet, emulated such valuable official guidance.

A second strand illustrating the government's capacity for occasional bold moves relates to the unemployment problem, in so far as it relates to S&T education. Since the 1980s, policy-makers have perennially expressed regret over the worsening low levels of employment among school leavers. As a practical solution, a National Education Review Commission recommended in 1985 that the most viable solution to the unemployment problem entailed the introduction of vocation-related secondary school subjects. This, it was expected, would cultivate a positive mentality towards locally available types of work and develop entrepreneurial skills among youth. However, the implementation of this idea was delayed for more than a decade mainly because of the fear of replicating the negative experiences of other African countries. Notwithstanding, a pre-vocational curriculum that emphasises the use of modern technological skills has been piloted by the MOE since 1998 in a number of secondary schools that are progressively being equipped with the requisite technological gadgets, through donor funds, for the chosen practical skills areas.

A third area of current change pertains to the sharing of responsibilities with government, not only for activating, but also for funding, S&T curriculum renewal activities. A measure of willingness to contribute towards S&T education has recently been indicated by some of the country's major businesses which have committed themselves to providing equipment for pupils' competencies in the area of Information and Communication Technology (ICT). Thus, since early 1999 preparations have been underway between the MOE and the private sector to purchase and install computers in a specified number of secondary schools per annum. This input is additional to the LISSIT curriculum research and development project referred to earlier which greatly benefited from the voluntary participation of industry throughout its activities during the 1996–99 period. Such enterprise could help cushion some of the familiar financial difficulties experienced in developing countries of failure to continue with curriculum activities that initially relied on short- or long-term donor grants or loans.

The three experiences of the 1990s described above signify a salutary shift from the country's near-total dependence on imported curriculum ideas, and the government's sole responsibility for propagating them, to the creation of a new sense of common ownership and joint responsibility between government and non-governmental groups for the country's educational affairs. The wide dissemination of such accomplishments within the country is important for generating some national self-esteem and thereby stimulating further ideas and activities that are likely to build up and sustain a desirable S&T culture among the youth and society. Hence, these examples provide evidence that locally-driven S&T education is progressing well, in that ideas for relevant action which subsequently become government policy are derived not only from within its own corridors, but also include the initiatives of various national groups. There will perhaps be a stage in future when tangible socio-economic benefits can be realised as a result of current co-operative efforts in advancing a scientific and technological culture among the school-going Swazi population. These positive outcomes are anticipated despite the numerous and powerful hurdles confronting school science.

Problems of S&T Education and Amelioration Possibilities

The phrase 'scientific literacy' appears frequently in the literature as a desirable school science goal for individuals and society. Recently, the American National Academy of Sciences (NAS) issued a set of 'national standards' for attaining a scientifically literate society. To this end, the academy stated that school science should enable individual learners to:

- Experience the excitement of knowing and understanding something of the natural world;
- Apply appropriate scientific concepts and skills in making personal decisions;
- Discuss public matters on science and technology intelligently;
- Increase their economic productivity by using their acquired scientific knowledge and skills in the workplace.

It is noteworthy that the four NAS statements are a recapitulation of goals stated since the advent of the Science, Technology and Society (STS) movement in the 1980s (Yager, 1990; Solomon and Aikenhead, 1994). Nonetheless, this repetition is valuable in that it reflects the difficulty of achieving these life-skills goals and is essential in the continuing search for strategies likely to help teachers steer clear of pedagogies that emphasise conceptual knowledge as the main aim of school science. An ancillary NAS document on the above standards is titled 'Project 2061'. This title is intended to convey the idea that scientific literacy goals are a long way from being realised; but that the effort towards their attainment should remain a continual process until entrenched expository methods are eliminated from the school programmes of future generations.

Some of the persistent and seemingly intractable constraints militating against the above goals in African countries such as Swaziland are worth recounting, for they justify current attempts at curriculum reform that advocate a contextualised teaching-learning approach.

First, all science curriculum reform in Africa has always endorsed the principle of practical work as the basis for learning, because this approach nurtures the development of virtually all of Bloom's (1956) educational objectives for cognition, as well as capacities for imagining and creating ideas. Regrettably, practical work is known to be a rare occurrence in many African science classes. Some of the reasons proffered for this paucity, such as the overcrowded classrooms that can be a severe problem for teachers, are legitimate. However, other defences are related to teachers' difficulty in shedding expository teaching methods and/or finding ideas for procuring or improvising resources. Notwithstanding, the quest for science classes based on practical work must continue because it is expected that the product of such a curriculum will not only know science, but will have continuously learnt to do or create something with their acquired knowledge. Regrettably, such practical capacities are never reported to have occurred as outcomes of Swaziland's school science system through public examination results.

The science curricula of developing countries must be potentially able to cultivate enduring higher order thinking abilities that are critically needed and are often facilitated by practical work. Such practical activities are not just about the repetition of standard experiments, but should be those that enhance pupils' ability to face challenges or create something, such as constructing a plan of action or modifying the structure of an existing local product. Black *et al.* (1985) refer to such practical work that appropriately links S&T ideas as a 'Task-Action-Capability' approach to school science.

A second noteworthy constraint closely related to the above limitations on practical work concerns a disturbing popular interpretation of success and achievement in schools, as reflected through end-of-year assessments. For the individual learner, success is about being promoted to the next class, through whatever yardstick is used by the school, and this adequately provides for the individual's satisfaction. For society, the focus of attention shifts to the number and quality of passes obtained by schools in public examinations. The public media spend much effort analysing which schools have performed better than others, thus fuelling and perpetuating the public understanding of success or high-quality education to mean the performance of schools in attaining the highest score from the group examined. This yardstick of evaluating successful learning is far removed from any of the goals for achieving the scientific literacy of individual learners. Nonetheless, a few Anglophone countries have expended some effort, through curriculum reform, in gradually removing this misunderstanding. To this end, goals for criterion-referenced assessments of the abilities of individual learners have been set up, starting with Britain's 'Attainment Targets' for different school levels during the late 1980s to South Africa's 'Outcomes Based Education' (OBE). It is to be hoped that many more African countries will want to change their perceptions of learning and will effectively borrow and lend one another various strategies for change.

A third persistent problem is the attitude which consistently portrays school science as an abstract and difficult subject. It is common knowledge that this image of science foments apathy towards science or engenders low self-esteem among learners. The problem emanates from an excessive or even exclusive emphasis on the content of the discipline to the extent that learners fail to see how the concepts and skills of science relate to their real world. As a result, the subject matter is rendered irrelevant and worthless in that learners cannot readily relate their lives to it or use it for dealing with everyday encounters. It is also common knowledge that science has become the prerogative of a few capable learners beyond the compulsory junior secondary school level because the majority could not cope with such an agenda. This exclusiveness was unsuitable not only for the egalitarian sensibilities of modern societies, but runs counter to the agenda of popularising S&T as the basis for the everyday thought and action of all individuals and the essential constituent of the nation's economic advancement.

A possible remedy for this long-standing malady requires the reconstruction of curricula that are meaningful to the learner in so far as the content overtly relates to relevant local contexts and applications. In addition, the curriculum must promote the learning of useful scientific knowledge and skills that have a practical bearing on the socio-economic welfare of individuals and their societies. In this regard, there is a clear implication for weaving a close relationship between school science and local technologies to reflect the fact that everyday encounters and problems often have both a scientific and technological aspect. Hence, the search for local technological contexts and applications, in order to link them appropriately with school science, is important for promoting a sense of useful learning that emphasises productivity, thus raising the chances for learners to develop capacities in problem solving and creativity. Science-related abilities such as being able to suggest the cause of an event, what might be done in a problematic situation, an awareness of how science affects the lives of people living in their community and how, in turn, people affect their environment, are of high priority in many African societies. In this sense, science education goals have become oriented towards the socio-economic development of individuals and their societies. This is the science educator's challenge for promoting popular science at the school level.

Similar goals are relevant for the general population, but different activities for various age groups can be set up to run alongside those focusing on the school situation. This perspective of school science has been reiterated in African forums during the 1980s and 1990s as part of the preparation for Africa's ability to take responsibility for its own development in the next millennium. The LISSIT project aimed at promoting this perspective within those forums that were engaged in curriculum reform for Swaziland.

This background of problems and aspirations takes us to the rationale and strategies used in the construction of the LISSIT curriculum material.

Teaching and Learning Relevant Science for All

Major school science curriculum reform during the latter half of the twentieth century in the English-speaking countries of the West has been consistently emulated by most African countries (Ajeyalemi, 1990). Studies of these reform movements by Roberts (1982) and Solomon and Aikenhead (1994) reveal that change has repeatedly been inspired by the need to achieve what was perceived at a particular time as relevant school science. Although some controversy exists about the notion of relevance, Wellington (1989), for instance, was of the view that it 'is of little value in planning the science curriculum', but that it cannot be easily discarded, for it does provide some measure of the value attached to a phenomenon at a given time and place. Hence, the science that is taught and learned is relevant in so far as it reflects what is regarded by a community as beneficial.

As one of the most recently stated goals for achieving scientific literacy (NAS, 1996) shows, the understanding of science by learners and consequently society as a whole has always been a prime aim of school science. However, relevance takes it cue from the interpretation of what this understanding entails or what its valued outcomes should be. Makhurane and Kahn (1998) identified two operational levels, 'high science' and 'low science', that have to do with worthwhile outcomes of school science in society. At one extreme, this continuum refers to science or technology research activities that contribute to the discovery of new knowledge; at the other, it relates to the various human activities that apply scientific and technological knowledge and skills to everyday encounters. Both these levels of S&T activity are vital for the advancement of African societies; hence, decision-makers and implementers of the science curriculum must ensure that both these expected outcomes are accorded equal importance. The main difference between the adult practitioners of these levels lies in the number of participants who will emerge as school science products for each of these activity types. In the present era of attempts to raise the consciousness of African populations of the value of S&T knowledge and applications for the development of their communities, the majority of citizens should expect to be empowered to engage in practical 'low science'. Such an outcome is of greater benefit than that of learners loaded with much school science knowledge that leaves the majority unaltered in their static non-scientific modes of thought and action. Science educators are therefore challenged to improve the quality of education by ensuring the availability and use of teaching and learning modes that are particularly amenable to raising capacities of the majority to, at least, the 'low science' category.

The LISSIT group responded to this challenge by constructing an illustrative set of curriculum materials that would project the method of teaching and learning scientific ideas through local contexts as highly relevant and feasible. The main lessons emerging from the LISSIT experience begin by responding to some of the current school science problems.

Relevance as meaningful and useful science

It was stated earlier that developing countries have stressed the need for meaningful curricula as a means to combat the negative image of a subject that appears abstract and difficult to understand. Science as useful knowledge should be added to the quality of meaningfulness when identifying and constructing contexts to facilitate the learning of scientific ideas. The first action taken was to decide on a theme to guide the construction of contexts. The LISSIT group agreed to focus on the country's production of commodities, ranging from formal large-scale industries to informal small-scale or everyday activities. The meaningfulness of subject matter would be expedited by the learners' possible familiarity with the depicted occurrence and its usefulness in that the issues would often relate to circumstances in local workplaces. In this way, the meaning of a science concept or skill was made real, understandable to the majority, applicable to local situations, achievable and therefore interesting, rather than abstract, irrelevant and therefore difficult. Learners could also visit the simple S&T sites portrayed in their learning material to improve the understanding of ideas and their usefulness. This link between subject content and the learners' environment should drastically reduce the elitist character of science and makes 'science for all' feasible.

It is, therefore, imperative that every effort is made by the science education community to identify and document local occurrences that learners can identify with. These findings, both indigenous and exogenous, must be analysed in relation to their links with S&T precepts. In this way, scientific and technological concepts are not learnt and understood merely for their own sake, but can be perceived mostly in terms of their fruitful purpose in the daily life of individuals and their communities.

Science for all

The shift towards a more utilitarian 'science for all' necessitates the development of intellectual and physical capacities that are within the learner's scope. The school science curriculum in Swaziland, as in other African countries, currently caters for differences in learner abilities and school conditions by fitting learners into different syllabus categories, ranging from the 'hard' or 'pure' sciences to the 'soft' or 'combined' sciences. Such arrangements have, to some extent, satisfied the 'science for all' principle. However current reform, as exemplified by the LISSIT's viewpoint, advocates that all learners should be exposed to meaningful, applicable and functional school science, at least up to junior secondary school level. Reports on the observation and assessment of classrooms using the contextualised approach indicate that this strategy yields valuable outcomes (Ramsden, 1992; George,

1999) to the extent that it should be regarded as popular school science for all.

Local co-operation effort

The second important feature of the context-based teaching/learning strategy emerges as a powerful means to combat Africa's reliance on imported curriculum ideas. A condition for the successful production of context-based material is the necessity for all contributors to be conversant with all vital aspects of the features and culture to be depicted as realities of local S&T in action.

If S&T education is to be for all, then all requisite resources, physical and human, should be aligned to the task of producing the relevant school science. In the LISSIT project, a sample of high-ranking technologists from a variety of local industries collaborated closely with a group of science teachers and educators to develop the contextualised teaching and learning materials. In fact, industry's contribution went beyond the provision of expert practical S&T knowledge to financing the participation of their technologists in the joint curriculum development venture. Research into the industrialists' reactions to their unprecedented participation in curriculum development yielded positive perspectives among most of them (Lubben *et al.*, 1998). This finding is an indication that continued partnerships with industry in S&T education are worth pursuing.

It is worth noting that varied reasons are proffered by different organisations for establishing links between school science and technology with industry. For instance, a cogent set of goals for Ghana's progress twoards becoming an industrialised country is described by Anamuah-Mensah (1999) as the rationale for school science links with industry. The LISSIT link with Swaziland's industry, through the development of materials for a syllabus that did not require the learner's familiarity with local productive processes, was regarded as a relevant step towards nurturing an interest in the country's productive sector. The possibility of preparing learners to be future workers, or pre-empting the requirements of industry, hardly featured as an aim. It was expected that this link between school science and the country's economic activities could promote in the young generation what a UNESCO-based effort of an earlier era referred to as the development of an 'S&T temper' (Irvine, 1985) among the peoples of developing countries.

Strategies for achieving the applied science approach

A government policy document calling for extensive school curriculum reform was issued in 1985, but little had been implemented to accomplish this goal a decade later. This lack of action challenged the country's science educators to provide some direction on how the desired curriculum renewal could be executed. Research findings in the country had shown low levels of cognitive ability among learners to apply their scientific knowledge in rational ways to various local situations (Putsoa, 1992). This weakness has been corroborated recently (Campbell *et al.*, 2000). The finding provided some guidance on the direction to follow in reforming the curriculum. Thus the project created a set of inquiry-based, interactive learning materials that modified the current junior secondary school science curriculum. The materials illustrated a strategy which maximised the meaningfulness and usefulness of science to learners and thereby minimised some of the serious problems of S&T education.

LISSIT was a University of Swaziland project. However, the project directors were convinced of the necessity for an all-inclusive reform activity characterised by the participation of a wide spectrum of stakeholders in the country's S&T sector. Thus, the project team consisted of participatory representation from the Science Inspectorate Division of the Ministry of Education, practising teachers from each of the country's four regions, industrialists representing a reasonable variety of technologies and science educators at the University of Swaziland.

Frequent reference has been made in this Chapter to contextualisation and in the literature (Lubben *et al.*, 1995, 1998; Putsoa, 1999) to three central components, contexts, applications and investigations that characterise the teaching and learning approach adopted in developing the materials. These elements are briefly explained below.

Contextualisation

Contextualisation refers to a teaching style based on linking local experiences that learners have, or are likely to encounter in their environment, with the relevant scientific ideas to be learnt. Experience has shown that these contexts, which serve as starting points to lessons, tend to diminish the abstractness of scientific ideas, promote their relevance to the learner's circumstances and raise the learner's interest in tackling the conceptual problem embedded in the story line created for each context. The identification of contexts related to the country's productive activities was the main research activity carried out by the project team of teachers who combed the rural and urban countryside while industrialists focused on events at their workplaces. The collaboration that occurred between the science teachers, educators, government inspectorate and industry representatives in working out appropriate contexts for each of the lessons of a syllabus topic was extensive. This was the highlight of the three-year long teamwork; it should augur well for valuable relationships in future between school science and the various technologies seen operating in different parts of the country.

Applications

Applications were included at different stages of each lesson to help learners develop the habit of tackling tasks that require their ability to select and apply their scientific knowledge to solve problems. Workplace activities, both rural and urban, that could be readily used in establishing and using particular scientific ideas served as valuable reference points for this component.

Investigations

Each lesson proceeded along an investigative route to help learners use a variety of inquiry skills and develop the capacity to design valid tests. These were laid out as a logical sequence of activities that started with the problem posed initially in the given context.

Throughout each lesson, learner participation, either individually or in groups, was encouraged through a wide variety of interactive teaching methods such as practical work, role-playing, model-making, discussion, creative writing, class or take-home exercises.

Main strengths and weaknesses of the approach

A sample of teachers who had not participated in constructing the materials were randomly selected from the country's four regions and asked to use the revised LISSIT material in their classrooms. They were informed that their role was to evaluate the effectiveness of the modified curriculum, especially on two aspects that reflected the desired reform. The first was on the ease or difficulty of handling LISSIT, with respect to the teaching and learning approach and the materials used. The second evaluation aspect was to be on pupils' abilities, skills and attitudes, with respect to classroom participation, cognitive activity, and attitudes to work and to people.

Teachers were asked to record their experiences and views in a daily diary and then summarise all views at a workshop.

Handling LISSIT in classrooms

A common theme running through teachers' descriptions of the teaching and learning approach was that it was challenging for most teachers because they were compelled to learn about technological operations that are a familiar sight in the environment, but which they had not previously concerned themselves about, such as a conveyor belt, a crane or a weighbridge included in the Force Unit. Teachers felt challenged to think of ways to help maintain a balance between the classroom fun aroused by an interesting context or local application used in the lesson and the orthodox science concept that had to be learnt. Further, it was not easy getting pupils to use the lesson's inquiry modes in order to think for themselves, or to convert their interesting practical observations into scientific explanations.

Finally, on the approach, teachers stated that the lessons successfully engaged pupils' interest, kept them working for most of the time and the various short- and long-term projects encouraged pupils' creativity, but the latter were problematic because they took too much time and effort to complete. With respect to the teaching and learning materials, it was generally agreed that these were easy to follow because of the guidance provided in the teachers notes and the answers to questions asked in the pupils workbook activities. The instructions written for pupils were said to be precise and simple to follow for most learners. The difficulties described were not just about weaknesses of the LISSIT approach and its materials, but were mostly those inherent in all S&T activity. For instance, teachers and pupils were disadvantaged in some lessons requiring electricity and/or technological equipment, such as video, that is not available in some schools. Also, pupils in schools that are far from modern technological activities could not begin to tackle lessons that required the modelling of ideas from observed action. However, rural pupils related well and easily executed work based on familiar contexts, such as the lessons on maize and on local housing structures.

Pupils abilities, skills and attitudes

Important observations were made on pupils' classroom participation. Teachers noted that the desire to participate increased noticeably as compared to pre-LISSIT classes. This change was evidenced by the fact that more pupils actually tried out the group practical work activities and the rate of collecting specified material from home in readiness for practical work improved. It was concluded that these inclinations to participate increased pupils' sense of responsibility for the success of their lessons.

However, there was dissatisfaction with some aspects of the material where the demands were said to be above the scope of learners. For instance, the intricacies of the weighbridge diagram 'do not encourage understanding'. Also, the inclusion of decimals for calculating proportions of animal skeletons to their body weight created difficulties. Teachers' statements on cognitive and other skills were also telling and the main theme running through their responses was that all lessons were thought to be provoking for learners. Cognitive growth was indicated by improved levels of discussion, such as when interpreting occurrences. The development of various investigative and creative skills, including the accurate observation of events, making models of tools for executing a task and perseverance, were encouraged, especially by the practical work requirements of short- and long-term projects. In addition, teachers noted an increase in the number of pupils able to tackle questions requiring the 'handling of information and applications' in monthly tests, rather than those of knowledge and understanding only.

On attitudes to science, work and people, teachers thought that the general feeling about science being abstract or difficult to understand was blunted as 'they started to realise that most of the things we do in our everyday activities involve science'. There was almost total agreement that 'pupils enjoyed most of the lessons' and their 'interest was greatly aroused' by classroom opportunities to share their personal experiences, their reasoning or appreciating one another's input. Teachers stated that this seemed to improve their disposition to apply themselves and this new orientation towards work was shown by the fact that 'most pupils did well in their continuous assessment marks of the third term, compared to the other two school terms' prior to LISSIT.

Another new feature emerging within the usual group work format was a new spirit of competition in 'producing the best model or to finish within the stated time'. Also 'some pupils considered academically weak became appreciated [by peers] for their out-of-school experiences, or their superior abilities in some practicals and group projects'. On the whole, the teachers' descriptions of their experience with the LISSIT material were what a curriculum developer would hope to achieve. Regrettably, current research on the effect of the contextualised approach indicates little success as regards the goal of cultivating enduring scientific reasoning abilities among learners (Campbell *et al.*, 2000). However, it must be noted that assessments of pupils are based on the outcomes of trials from extremely brief projects such as LISSIT. Nonetheless, the three elements titled contexts, applications and investigations described above are worth including in the S&T curriculum efforts of other African countries.

The Way Forward

The African Forum for Children's Literacy in Science and Technology has been a tireless source of inspiration for ideas and material support to a large group of individuals and institutions in many parts of the continent. AFCLIST has continuously forged ahead into new levels of action aimed at engendering a fresh resoluteness among African S&T educators to collaborate in eliminating the perennial factors that adversely affect the continent's quality of education, which, in turn, inhibits its ability to benefit materially from years of input to education. To this end, AFCLIST has established centres or nodes in different countries whose task is to stimulate developments likely to ameliorate identified qualitative problems of S&T education. Currently, Swaziland collaborates with Ghana in taking charge of the node on 'Linking School Science and Technology' with that on the 'Community and Workplace'. The centres established in these two countries are referred to as sub-node and node, respectively, and they are keen on attracting the participation of other African countries in node activities. The main factor that motivates the node's existence is the development of Africa's human resources in a way that is imbued with crucial scientific and technological values and skills needed for the continent's socio-economic development. The node expects to achieve this goal through reformed approaches to school science teaching and learning and reconstructed materials to reflect realities that are within the learner's grasp. This reformulation has to be rooted on a firm research base. Hence, among the variety of activities thought to be critical for effecting beneficial changes in S&T education is research into the various S&T features in African communities, both indigenous and modern, that have been ignored by school science over the decades. Inevitably, these changes will affect the country's education policies and must occur in partnership with all parties interested in popularising science and technology.

Conclusion

One of the greatest challenges facing many African nations is their ultimate ability to extricate themselves from an excessive dependence on Western nations for ideas and material support for the basic survival of its peoples. The apparent inability to work out practical ideas and action co-operatively for the benefit of the nation as a whole has been a characteristic feature of many decades of post-independent Africa. This incapacity can be readily associated with indolent states of mind cultivated over many years of dependence on instruction for action, through home and school education, as against questioning and tackling issues intellectually as they occur. This incapacity is contrary to the nature of science which is associated with rational thinking. There is need for a bold declaration on a school science agenda that focuses specifically on the development of rational thinking abilities among school leavers.

Information on the potential for attaining beneficial levels of economic development from the continent's plentiful natural resources is well documented. Unfortunately, the science and technology intricacies of this data remain unknown or unused as one of the curriculum strategies for nurturing pupil's cognitive and other critical skills that encourage a positive interest in African affairs. Conversely, the dissemination of information on the creative abilities of ordinary local citizens, as evidenced by the productive activities in the informal sector of the economy that closely relates to the everyday needs of the majority, is inadequate. The challenge to all those responsible for the country's advance, such as policy-makers and educators, is to be proactive in identifying and celebrating the creativity of ordinary people in the workplace. These abilities and products must also be regarded as vital national assets to be studied and improved upon. This could be one way of boosting the nation's self-esteem.

Each African country will achieve desirable levels of socio-economic development through the efforts of its own people, rather than those of donors. Hence, the government must work use its own national expertise in the search for and analysis of valuable human assets and S&T activities as part of the solution to existing 'poverty' problems. In this regard, continual research and reliance on its outcomes for making policies and effecting them will be crucial because African nations cannot escape the intensive competition for high-quality products imposed by the current 'globalisation' phenomenon. In this context, it is imperative for each developing country to identify its own human strengths that can be harnessed and genuinely incorporated into a strategy for developing an S&T culture and abilities that could transform the majority of its people from a consumption mentality towards a productive reality.