International Institute for Capacity Building in Africa

Role of Teachers in Motivating Students' Interest in Science and Mathematics

By Professor Uduogie Ivowi

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Introduction

Over the years, students' performance on public examinations in Science, Technology and Mathematics (STM) has been poor (e.g. Ivowi et al, 1992; Adeyegbe, 1993; Adeniji,1998). Many sources of poor performance, spanning both students' and teachers' factors, have been provided in the literature. Since students' performance dominate the yardstick upon which data could be collected to ascertain their interests in STM, it is reasonable to focus on how to motivate such interest in students. Again, STM abounds essentially in the classroom, workshops and laboratories where the presence of teacher is highly crucial and beneficial. In doing STM, the role of the teacher in motivating students' interest in those subjects cannot be in doubt. Although these students', as learners, have complete responsibility for what they learn, they are to be guided by their teachers in their quest for knowledge. With proper interaction between teacher and students, interest in STM can be developed and sustained.

STM is crucial for national development. Since youth are expected to be involved in the development of the nation, they need to be well grounded in STM in order to cope with future activities. To succeed in this venture, their interest in STM needs to be sustained once it is generated. To sustain interest, it is necessary to ensure that the population of students is adequately catered for by taking measures towards gender fairness and balance. But there exists already sufficient biases against the girls in STM: therefore, extra care needs to be taken to ensure that girls' engagement, performance and interest in STM are enhanced. More importantly, the wide ability ranges between boys, and girls, and among boys or girls, need to be recognised and provided for.

Given the concepts of interest and motivation, it is necessary to ascertain their effects, and manifestation, while attempting to ensure their generation and sustenance. These and the specific roles of teachers in instructional strategies together with the possible assistance to teachers to enable them to perform their obligation to students will be examined in this paper.

Interest

By ordinary meaning of the term, interest is a state of concern or curiosity. It is to cause to become involved in something. To show interest in a thing is to be actively involved with that thing; to show concern for or have curiosity in that thing. To be interested in science and mathematics involves showing sufficient concern for and curiosity in the subject by being activity involved in all activities related to the subject. This will entail doing science and mathematics in all their reifications.

Interest in science and mathematics can be manifested in many ways, some of which include:

- reading texts in the subject area;
- developing related attitudes and attributes such as curiosity, logicality and evaluation;
- manipulation of devices such as a tools and equipment, and of data;
- display of data in various forms; and
- application of related concepts, principles and ideas in varied situations.

A major effect of interest in any endeavor is significant display of efforts in the area. Such efforts could be seen in terms of repetition of activities without a feeling of boredom, improved performance in related undertakings and originality or innovation in the area of concern. A feeling of fulfillment becomes inevitable particularly as novel applications result with the display of the use of problem-solving strategies.

It is not easy to generate interest if the potential is not there. Interest can be more easily aroused but unless there is a concrete factor to sustain such interest, it may soon be lost. An intrinsic or extrinsic motivating factor becomes necessary in the generation and sustenance of interest in any subject. For science and mathematics, interest can be generated by many factors such as:

- novel demonstration and applications:
- relevant illustration;
- simple explanations of common phenomena and events;
- successful demonstration of results from manipulation of devices; and
- stimulation of creativity;

There is no doubt that these are not easy to achieve; but an element of perseverance is needed to succeed. This is where the teacher, with experience and determination to excel, can play a major role in stimulating interest in students.

Motivation

To motivate is to instigate or incite. A student's desire for knowledge, need for achievement, ego-involvement, interest in a particular subject matter are all explained by motivational attitudinal behaviors (Akibye, 1996). As he stated further, such behaviors critically influence a student's attentiveness, degree of commitment and concentration on learning. Motivation is an important factor in learning generally and school learning in particular. It may be intrinsic, as in the case of personal satisfaction and self-fulfillment; or extrinsic, as in the case of reward of an enchanting position or award of material benefit or recognition in society.

Motivation, according to Akiboye (1996) affects learning in three ways:

- It triggers off behavior sequences in the learner when it is

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The Editor
IICBA Newsletter
P.O.Box 2305
Addis Ababa, Ethiopia Africa
Tele: (251) -1-557587
Fax: (251) -1-557585
Email: info@unesco-iicba.org
Web site http://www.unesco-iicba.org

present; and since learning is said to be reaching, the learner so activated attains learning readiness.

- It is said to lower the threshold of reinforce ment, so that reinforcement can more easily be contingent on learning.
- It could serve as prompts or stimulus discrimination for learning.

Apart from these effects of motivation on learning, manifestations of motivation can take many forms, some of which include the following:

- Increased attentiveness in class and in learning situations;
- Improved degree of commitment by positive response to assignments; and
- Increased degree of concentration in learning which could result in better display of understanding of content and attainment of skills.

Since motivation could be intrinsic, an encounter with the goodness of a cause like a subject matter and a display of an enabling environment could aid the generation and sustenance of motivation. For the extrinsic factor, relevance of the subject matter to one's concept of life and aspiration plays a major role in being motivated and remaining in that state while learning is taking place.

Since teachers interest with students, and teaching/learning materials as well, guide the students in their learning encounter, their role in motivating students' interest is significant, and even more demanding when such interest needs to be sustained.

Teachers' Role

Given the crucial role of teachers in a learning situation, they must affect students' interest in science and mathematics, like all other subjects. In particular, focus can be placed on two areas where the teacher plays a major role. These are curriculum provisions and instructional strategies. As indicated earlier (Ivowi,1996), these are capable of sustaining students' interest in science (including mathematics).

For curriculum content, some of the measures for sustaining students' insert include:

- Provision for wide ability ranges;
- Provision for various interest within the three domains of education objectives;
- Provision for various subjects in the curriculum;
- Provision for various applications of subject ;
- Provision for stimulation through readers series and co-curriculum activities.

Details for this are discussed in Ivowi(1996); and since teachers are key factors in the development and implementation of science and mathematics curricula, their role here relates to the motivation of students' interest in the subject matter. But the provision of curriculum materials is not enough to ensure the sustenance of students' interest in science and mathematics; the way the material are taught to students matters a lot, not only for learning to take place but for learners to make efforts for learning to occur.

Good teaching and use of relevant techniques are some roles which the teacher needs to play to arouse and sustain interest in students. Some factors which determine good teaching are:

- the teaching technique employed;
- the feedback mechanisms adopted;
- the reward system advocated;
- the influencing variable taken cognisance of by teachers; and
- the range of pedagogic strategies available to the teacher.

Some of the techniques advised for use during the period of interaction between the teacher and the students include.

- Questioning and jokes so that student's' attention is assured;
- Discussion aimed at fully involving the students in the process of teaching and learning science and mathematics;
- Practicals for the purpose of giving the student an opportunity to do science, to find out the truth and verify claims in order for meaning to be attached to the science lessons;
- Fields trips to see things in their natural environment, appreciate applications and eliminate boredom;
- Projects for the purpose of allowing students to do some independent investigation by consulting literature, peers and other persons;
- Summary to present in a form which coincides with what has been taught, for ease of reference and appreciation.

The purpose of learning is for full understanding to occur; and this happens if a whole concept or principle is completely understood in terms of structure, application and relevance. Therefore, teaching and learning take place, and feedback is needed. This has its various forms.

As stated by Gipps(1995), there are influencing variables which teachers must take cognisance of in order to sustain students' interest in science. These include:

- Different cognitive styles of different groups of learners;
- Different motivations of different groups of learner;
- Variation among groups of girls; and
- Variation among groups of boys;

Given these, a range of pedagogic strategies needed by the teacher includes;

1. Materials and contents;
2. Teaching styles;
3. Classroom arrangements/rulers for different learners and different subjects;

In addition, Gipps (1995) indicated the variations in pedagogic strategies which teachers need to be made aware of and encouraged to use in order to enhance the performance of girls. These are equally relevant for students' interest in science and mathematics to be sustained and performance improved upon. Only four of such variations will be mentioned here:

- Linking scientific and mathematical content to society;
- Emphasising discussion and collaboration as well as competition;
- Private as well as public questioning and probing of the pupil by the teacher; and
- Giving feedback which criticise and gives precise guidance (in a supportive manner) as well as praise, rather than the bland praise (for dutiful hard work) which girls currently tend to receive.

There is no doubt that enormous responsibilities abound for the teacher, which, as can be seen, are both within and out side the classroom, and both public and private. To be able to shoulder these, the teachers themselves need to be assisted.

Assistance to Teachers

In order for teachers play their role of motivating student's interest in science and mathematics, the following pre-requisites of our concern for teachers are necessary:

- Teachers should be seen as motivators to students in their endeavor to learn science and mathematics inside and outside the classrooms;
- Teachers need to be encouraged to perform their role in the motivation of students' interest in science and mathematics by a number of positive measures to enhance their prestige and professionalism; and
- Teachers need to be empowered as aids to quality performance of students in school as they keep standards and make students to internalize affective attributes.

But while expecting the above, specific measure to assist the teachers in their role include the following:

- Providing of adequate and suitable facilities to enable the teacher to perform as expected and as desired by them;
- Motivating the teacher themselves through various welfare packages and professional development;
- Ensuring regular and frequent monitoring of teachers to enable dialogue to be held particularly on issues affecting their welfare and profession; and
- Providing teachers with various incentives such as awards, recognitions and competitions.

Conclusion

The teacher plays a very crucial role in motivating students' interest in science and mathematics as indeed in all other subjects in the curriculum. Given the indicators of both interest and motivation and an identification of their manifestations and effects, it becomes fairly easy to attempt to generate and sustain these in students. Seeing teachers as motivators of students' interest, and assisting them by providing for their welfare, professional development and providing a conducive atmosphere to enable them to practice their profession, it is asserted that teachers can indeed motivate students' interests in science and mathematics in school. And this should be our mission and vision.

From: Perspectives on Education and Science Teaching

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Teachers are the Problem, not Girls!

Joseph P O'Conner

FEMSA Regional Coordinator

Introduction

The central goal of the **Female Education in Mathematics and Science in Africa (FEMSA)** project is to improve the participation and performance of girls in Science, Mathematics and Technology (SMT) subjects at primary and secondary school levels and to invigorate ministries of education and policy makers to make the necessary adjustments in curriculum, teacher training and examinations to ensure fuller participation and better achievement in SMT subjects by both boys and girls. A second important objective is to develop innovative, interesting and girl-friendly approaches to the learning (it's all about helping the girls to learn, not about teaching them!) of SMT subjects which will take into account girls' out of school experiences and their needs in life after school. A Mid-Term Review of Phrase II of the FEMSA project was carried out during July and August of 2000. In the course of the MTR report on project activities in Tanzania by Dr. Anna Obura, the leader of the Review Team, the following startling statements were made.

"Constant reference is made in the project programme to problems rather than to issues, as if everything related to girls is a problem and as if girls have nothing but problems, problems, problems. It has to be said that this is not a view unique to Tanzania. On the contrary.

However, this constitutes a gender problem in itself, a gender bias which works consistently against a positive image of girls when girls are constantly referred to (in a GE programme!) in terms of girls' problems. In-depth analysis reveals that the problems that girls face may lie in the hands of people beyond girls, and it would be more correct to speak of the problems of those other people than call them girls' problems. If girls have to face negative experiences as a result of the problematic attitudes and behavior of other people, then indeed girls do have a difficulty to face, or a problem in this sense, being the victims of others' attitudes and actions. However, in order to turn attention to the causes of 'girls' problems', it would be salutary to talk of societal problems or the problem of those other people who cause difficulties for girls, or to refer to the resulting difficulties of girls. The onus is on us all to find more conceptually clear terms in which to express these phenomena."

The objective of this article is to focus on some of the problems posed for girls, in their learning of SMT subjects, by teachers and teacher educators as revealed by the FEMSA experience.

Problems Posed for Girls Learners of SMT by Teachers

Over a two-year period the four Phase I FEMSA countries, Cameroon, Ghana, Tanzania and Uganda, carried out a detailed study of the status of girls' participation and performance in SMT subjects in primary and secondary schools. It was found that fewer girls than boys have access to SMT studies, and that girls generally perform less well than boys. These findings were borne out by small-scale studies carried out in the eight new Phase II countries, Burkina Faso, Kenya, Mali, Malawi, Mozambique, Senegal, Swaziland and Zambia. The attitudes and approaches of teachers were found to play a major part in this state of affairs across all twelve countries. It is interesting to note that teachers generally see themselves as blame-free for this situation and seem unwilling to find any fault with the syllabuses, examinations or indeed their own teaching approaches. They tend to accept the situation as being almost inevitable and out of their control.

Only after prolonged probing of the situation does the realisation dawn that, yes, perhaps something could be done about the situation at the school levels. On the other hand, students and parents are much more critical of teaching approaches, syllabuses and examinations.

The FEMSA studies reveal that the following are the major areas which contribute to teacher fostered problems for girls.

- **Attitudes of teachers**
- **Poor Expectations of Girls' Performance**
- **Classroom Dynamics**
- **Insensitive Teaching**
- **Didactic Approach to the Learning of Mathematics and Science**

Attitudes of Teachers

There is a strong, all-pervading, traditional, conservative belief among parents, teachers and students that mathematics and science subjects are a male preserve. The attitudes of teachers has by far the greatest impact. Many teachers, including women teachers, despite much lip service to the equality of girls and boys, just do not believe that girls have the ability to study mathematics and science: they believe that these disciplines call for struggle and determination and they simply do not believe that the girls are capable of coping with "difficult" subjects. Among women who have succeeded in mathematics and the sciences there is a strong belief that teachers actively discourage girls from studying these disciplines. The result is that teachers generally have low expectations of girls' ability perform well in SMT.

Poor Expectations of Girls' Performance

The following set of statements by a Maths or Science teacher reading out the results of a termly test is common in many classes.

> *Mary Kiarie, 37%. Mary! You have really tried during this test!*
> *John Simiyu, 73%. Hey, my friend! This is not good enough! You must really work harder next term!*

Has this kind of scenario been a feature of your SMT classes?

Classroom Dynamics

Poor expectations of girls' performance leads to the kind of SMT classroom dynamics, where girls are treated very differently from boys. Class observation revealed that teachers do not encourage girls during SMT lessons, and in fact, at times, actively discourage them. One way they do this is by directing only simple recall type of questions to them and directing the more difficult, reasoning type of question to boys. There is often a misguided effort on the part of teachers to save the girls from potential difficulties with SMT and to save themselves from having to teach the girls, which they claim would require 'enormous effort'. This kind of treatment can only reinforce and confirm in the minds of both boys and girls what society and literature peddles around 'that science is for boys only'. Boys therefore, over time, develop at these subjects which they consider a male domain. They harass the girls and regard them as being incapable of engaging in difficult learning tasks such as handling SMT subjects.

Girls shy away from any active participation during SMT lessons, for fear of letting themselves down in front of their peers, but more, for fear of being taunted by their male classmates. Taunting of girls by boys in schools is a serious issue that intimidates some girls to an extent that they never voluntarily offer to answer any questions in class. Because SMT subjects were considered masculine (therefore 'unladylike'), many girls were reluctant to try and excel at these subjects, as this would draw attention to them in ways that would make them feel uncomfortable. Girls complain that boys call them names when they try to ask teachers questions. Boys, on the other hand, blame girls for being unable to stomach jokes and name calling coined out of terms learned in science classes. And this situation is tolerated by many teachers and school administrations.

The research showed that there is rampant harassment of girls by their male schoolmates and at times, male teachers too. This harassment may be sexual, physical or emotional, instilling fear in the girls to the extent that girls rarely go to male teachers for help.

Insensitive Teaching

Many teachers are unaware of the special difficulties that girls face in the learning of mathematics and science: they are insensitive to the different out-of-school experiences which girls bring to the study of the subject; they do not take account of the anxiety many girls undergo when topics such as reproduction are dealt with in the classroom, or when girls are asked to use unfamiliar equipment and apparatus, or cope with live specimens; they do not understand when girls, especially from traditional and conservative backgrounds, seem unwilling to enter into discussions or ask questions, especially in mixed classrooms.

Didactic Approach to the Learning of Mathematics and Science

Parents who participated in the group discussions identified use of inappropriate teaching methods as one of the factors that contribute to the low participation and performance of girls in Mathematics and Science. They felt that the teaching methods used were not practical enough and that teachers made little effort to relate the concepts learnt and the examples/illustrations used to real life, especially within the context of the pupils' own lives and environment. They felt this had a negative effect on pupils' interest and motivation to study SMT subjects. The entrepreneurial skills of market women, kiosk owners and street vendors involving quick-fire mathematical calculations; instant judgment of what is a good buy or a good sale; and the means of mathematical reckoning they use; the use of patterns in tailoring and dress-making as an example of symmetry; the kind of geometry involved in basket weaving, tile making, bead work, hair styles, so beautifully exemplified by Paulus Gerdes in his magnificent book Geometry From Africa, etc., are never mentioned in mathematics classes. All kinds of modern and complex mechanical examples of friction are quoted in science classes, but the grinding of grain into flour, carried out by millions of women every day is ignored.

The sentiments expressed by the parents were reinforced by the findings of the classroom observations carried out as part of the school studies. The findings, which were strikingly similar in all the countries, indicate that teachers favour teacher-centred, knowledge based teaching methods that leave little room for learners' participation. The most commonly used teaching methods at both primary and secondary level were found to be lecturing; question and answer; explanations of procedures and note giving, in that order. Little practical work is done due to shortage of equipment and consumables, and the development of a scientific way of thinking is abandoned in favour of the learning of nomenclature, definitions and stock standard procedures.

If we are to have meaningful and sustained development in sub-Saharan Africa, we cannot afford to deprive over half of the population of the region in virtually every country from the long-term and vitally essential benefits of SMT. We need not merely to increase the number of women engaged in careers as professional scientists, mathematicians and technologists and other science-based occupations, but to enable the ordinary peasant farmer to avail of the many new technologies, improved farming and animal husbandry techniques, simple labour saving devices, and increased knowledge of environment and soil and water conservation, and the basic knowledge to provide a healthy home and family. We must provide every girl with the basic scientific, mathematical and technological expertise which will enable her to better solve her everyday problems and enrich her life in the village and on the *shamba*.

Conclusion

I have tried in this article to outline some of the ways in which teachers of SMT subjects create problems and difficulties for girls in their learning of SMT disciplines, as revealed in the FEMSA studies. I hope it will lead to some reflection on the part of SMT teachers, an examination of the approaches we bring to creating a learning environment for girls (and boys), a willingness to make these disciplines accessible to all students (and the girls' most consistent cry is Why can't they help us to understand?), and through a more thorough understanding of the problems help to alleviate the girls' difficulties. And I would like teacher educators to give serious thought to what might constitute the core ingredients of a girl friendly teaching/learning methodology, which could be introduced into normal classroom practice and both in-service and pre-service training of SMT teachers, and to sensitise their students to a realisation of the constraints and difficulties faced by girls in their learning of SMT, which are brought about by the attitudes and actions of teachers.

I would hope that in future articles I might have the opportunity to make known the kind of interventions which FEMSA has been implementing in order to improve the participation and performance of girls in SMT. I finish with a further quote from the Tanzania MTR report on the effects of these efforts.

Girls are happy - many are ecstatic about SMT. They talk in wonder about how they have found their place in SMT classes. Their faces light up and they laugh as they compare their new-found confidence with the dismal experiences they had a few years ago and the expectations they had of themselves faced with the continual prospect of failing in maths and science classes. Teachers, too, share this enthusiasm. They are getting used to explaining to visitors about their newly performing SMT girls. They are proud of themselves and the time and effort they put into FEMSA activities.

Major Elements of Science and Technology Education for all in Africa: Views from Botswana

Marianne Nganunu

Ministry of Education, Botswana

Introduction

It is now becoming evident to an increasing number of educationists that the education designed as it was, for the academic elite, cannot be applied in the same form when educational opportunities are opened up to the whole population. At the same time there are educationists who prefer to see mathematics taught in its traditional form and who fear that science might be polluted by the inclusion of technology. Faced with these two contrasting views, many countries, Botswana included, have ended up with some 'compromise curriculum'. This is a curriculum that includes some purely academic material which is regarded as an essential preparation for those who proceed for further studies as well as some real-life skills and topics which have been put in to cater for the early school leaver - which in most African countries will constitute the majority.

The end result is that some parts of the curriculum, i.e. portions that exclusively prepare for higher academic studies such as transformations in mathematics and using a pipette in science, are of no value to the majority of students. On the other hand, it is difficult to identify a part of the curriculum aimed at the early school-leaver which is not also relevant to those who proceed for further studies, be it fixing a bicycle or learning how to open a bank account.

'Education for all' does not merely refer to making school places available to all, but to making education available to all, i.e. providing education that all can benefit from. An education for all programme, including a science and technology for all programme, should cover knowledge and competencies - all of which are relevant to all students.

The Outcome

To identify the key elements of any education programme the desired outcome must be well defined. This will vary from nation to nation, but some broad goals may be applicable to the whole of Africa.

The World Declaration on Education for All (WDEFA) defines education from the individuals point of view and states that education should provide the tools, knowledge, skills, values and attitudes 'required by human beings to be able to survive, to develop their full capacities, to live and work in dignity, to participate fully in development, to improve the quality of their lives, to make informed decisions, and to continue learning' (WCEFA, 1990).

At the national level the goals may be more specific. 'Governments are insisting that education in general, and science, mathematics and technology in particular, should play their part in improving national productivity and enhancing the employment prospects of young people' (Power,1999). For example, the Botswana Government states as one of the objectives of education 'to prepare children for a useful, productive life in the real world' (Botswana Government, 1990).

Education must lead to the ability to earn an income. Without the ability to earn an income the problems related to poverty, dignity and quality of life cannot be solved. This is of particular importance to our continent where poverty is still common and unemployment rising.

What role can science and technology play in this content? Everyone, in their daily lives, comes into contact with science and technology. People who cannot use and understand the available technology are left behind in development and in the competition for survival - both as individuals and as nations. But it is more than that. The youth also have to prepare for the technologies of tomorrow and the development that results from these technologies. 'The world we live in is dominated by change related to development' and 'the pace and volume of change are constantly increasing because of science and technology'. Today's young people must 'keep up' with this change; they must be prepared for technology that has not yet been invented, and be able to design solutions to problems that do not yet exist. (ICASE/UNESCO/COMSCE, 1992).

A New Approach to Curriculum Development

A common approach to curriculum development is to look at the existing syllabi and see how they can be revised in the light of changing objectives. This, in the best of cases, can only lead to a 'compromise curriculum'. In moving from an education designed for the elite to an education for all programme, the whole education provision must be viewed with an 'expanded vision' (WCEFA, 1990). The first and foremost criteria must be to provide education that people can use.

This would involve identifying what people do in their daily lives and also what they need to do in order to achieve the WDEFA goals or the equivalent national education goals; then identifying the tools, knowledge, skills, values and attitudes required to research these goals. Only after the desired objectives have been identified, would it be appropriate to identify the subject or subject areas required to provide this education. This approach is important especially as many of the new components of education either cover a whole range of subjects or may not fit into any of the existing subjects. New educational goals might lead to a combination of existing subject or the creation of new ones.

Science and Technology might be one of these new ones. A science curriculum that deals with real-life issues must by necessity have a large and significant component of technology as the applications of science are technical (Nganunu, 1991). The UK National Curriculum Science Working Group expresses it thus: 'technological applications... can often provide contexts through which scientific concepts can be more effectively introduced and developed'. Technology, on the other hand, which involves devising practical solutions to problems relating to human needs, draws heavily on the knowledge and skills of science. (UK National Curriculum)

To ensure that the curriculum meets the need of the individual in a particular society the curriculum must be developed from within. The era of inheriting, copying, or adapting foreign curricula - until recently a common approach in Africa - must surely be gone by now. The experiences of other countries will come in at a later stage in the curriculum process, for example, when ideas are needed on how to impart a certain skill or how to handle a new technology, for example, computer education.

Science and Technology for All

A science and technology for all programme must prepare for change. The focus must therefore be on the development of skills. The skills will not only help students to find out, understand and use the scientific knowledge and technology of today, but also to find out, understand and use the scientific knowledge and technology of tomorrow.

Skills, however, cannot be taught without a context. This context should be of the scientific knowledge known today and the technology as it applies today to everyday situations in the community for which the curriculum is being developed.

The broad areas of science and technology that relate to survival and quality of life, and hence should be included in a science and technology for all programme, are:

(i) health,
(ii) the environment,
(iii) technology,

and I include food and agriculture in the environment area. By analysing the daily activities of people, in their homes and at work, the most relevant context areas can be identified.

It is of utmost importance that these skills are taught in a familiar context. For a student to engage in any kind of inquiry or problem solving activity, he/she must work with issues and materials that are familiar and easily accessible. If the task is an environmental problem, the problem should ideally be one that affects the immediate community and the solution should be one that that same community can use. The benefit to the individual and the relevance to real-life should be apparent throughout.

The basic skills required are very much the same for all people. For example,

- whether you are running a small business from home or a large manufacturing plant, you need the ability to adapt to current demand, communication and inter-personal skills to sell the goods, plan your work, evaluate your methods, and make use of available technology to increase productivity.
- whether you depend on subsistence farming or intend setting up a large agricultural project, you need initiative and self-motivation to get started, you must reason and make decisions on what and where to plant, maybe experiment and evaluate methods, solve problems, etc. before a successful results is produced.
- to make an informed decision, be it where to position a pit latrine or how to dispose of city waste, you need knowledge of the factors involved or knowledge of how that information can be obtained, you need to think critically and reason before making a decision.

By using the above examples I want to demonstrate that the basic skills required by people are very much the same whether you are a literacy participant, and early school leaver, or a highly educated person. These are skills that all people require in their daily lives, at home and at work, and hence should be taught in a science and technology for all programme.

Many of the real-life skills - communication, creativity, thinking, taking responsibility, decision making and so on - are not specific to science and technology. However, science and technology can contribute to the learning of these skills. For example, take an important topic like health. The most important aspect relating to quality of life is how to maintain good health for oneself and one's family. In a science and technology for all programme it is therefore necessary to go beyond the academic content of a standard biology textbook on, for example, the structure and function of the heart, and ensure the curriculum provides useable advice on nutrition, exercise, smoking and so on. And since such information could change with new scientific discoveries, the emphasis should not be on 'the right answers', but how to find out information, research into current opinion, discuss the issues, make your own judgement, and take responsibility for your own health.

Other life skills are best taught through science and technology. For example, environment and agriculture provides excellent vehicles for learning skills of scientific inquiry, and the technology for solving problems.

A scientific inquiry into the cutting of trees for firewood, or the introduction of a new industry into the local community, would provide students with skills-- of 'systematic observation, making and testing hypothesis, designing and carrying out experiments, drawing inferences from evidence, formulating and communicating conclusions, and so on (UK National Curriculum).

A technology problem-solving activity, such as producing a building brick of best possible quality with locally available materials or finding a way to water a vegetable plot with minimum waste of water, would provide students with skills of thinking, planning, designing, experimenting, evaluating and making. To be able to find your own solution to an identified problem is the only way students can be prepared for the problems of tomorrow, the ones that are not yet known.

By emphasising the development of skills, the real-life context, the opinions of and the benefits to the individual, and by personalising the experience, there is a greater chance of instilling the values, attitudes and behaviour that contribute to personal fulfillment and lead to responsible participation in the community.

Providing for the Wider Ability

Any education programme must start out where students are, i.e. be based on the knowledge they already have and match their conceptual level. This of course varies within any group and, as learning goes on, some progress faster than others. Therefore, within any science and technology for all programme, there must be scope for individualisation and special needs. For example, 'communication' is a tool every student will learn the same thing in the same way or reach the same level of competency. There should be a lot of flexibility in teaching/learning methods to accommodate the different abilities and interests. There must be opportunities for advancement for the fast-learner as well as stimulating activities for those with learning difficulties.

A technology problem-solving activity could range from being a very elementary one of purifying drinking water to a very advanced one of programming a computer to control a process. By allowing students to identify for themselves a problem that is interesting and worth investigating, or to design the procedure to be adopted', interest and commitment will be increased (Hodson, 1990) and, although the learning activity - solving a problem - is the same for all, the content (the problem) is adapted to the conceptual level of the learner.

Further individualisation can be achieved by allowing students to set their own short-term educational goals - guided by the teacher - and then attempt to reach these goals. This is also a way to develop self-motivation and responsibility for oneself. Students could make their own work plan, based on ideas provided by the teacher as well as on their own, and are then assessed on their ability to carry out what they had themselves planned to do.

Assessment

An 'expanded vision' on education assumes a similar 'expanded vision' on assessment. There has been considerable curriculum innovation in primary schools in Africa since the SEPA initiative, but the implementation of curricula has been restricted by assessment. Young pupils are often allowed to engage in fairly open-ended investigations and simple project work, but as they move higher up teachers are forced to change the teaching methods in preparation for the school-leaving examination. The examination, in most cases, test content and knowledge of pre-determined experiments - not research skill, independence, self-motivation and the like.

According to Hodson, to remove this opportunity for unstructured personal investigations from the students 'at the very time of their lives when they are struggling to establish their individuality' leads to loss of interest and enthusiasm for the subject. He states that 'the motivation of older learners often requires a cognitive stimulus, such as the exploration of ideas, the investigation of inconsistencies or the confrontation of problems' (Hodson, 1990). Our highly examination oriented education system does not allow for this.

The whole issue of assessment must therefore be reviewed in line with an 'expanded vision' on education.

Conclusion

Will a science and technology for all programme put students who are proceeding for further studies at a disadvantage? This of course depends to what extent teachers can individualise the teaching so that students can develop at their own rate. However, a science and technology for all programme which focuses on skills development is likely to provide a better foundation for further studies than the traditional approach of exposing students to academic content matter at an early age. In a recent study on human resource development for post-apartheid South Africa one of the problems identified as a cause for the high university failure rates in science and mathematics (including students from well-provided schools) was the 'narrow academic education' provided in schools which fails to produce 'creative thinkers', (Swainson, 1991).

Regarding the real-life skills, it should be remembered that even those who proceed for further education eventually have to enter real-life and the world of work. 'Even the high-technology scientist needs to relate to real-life and, in particular, to understand how technology affects the environment and society'. (Nganunu, 1991).

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Science Education Reform in Namibia

C. U. Tjikuua
Ministry of Education, Namibia

This paper was originally prepared for the workshop, the Secondary Science Education for Development (http://www1.world-bank.org/education/scied/Training/training.htm), which was organized by the World Bank, Human Development, Education Group in April 2000. The workshop aimed to explore some of the issues involved in science education reform within a larger context of social and economic development.

Background

Prior to independence in 1990, Namibia was politically characterized by segregation and separate development for different ethnic groups. Schooling in general was a privilege of a few and Mathematics and Science Education was predominantly for the whites, which constitute a very small percentage of the population. The South African government with its apartheid policy, advocated education for the black people as a vocational utility, supplying semi skilled and unskilled labour. The result was that, at independence, very few Namibians were trained in science related fields. Skilled labour for fields requiring such skills had to be imported from elsewhere when the South Africans pulled out at independence. In addition, lack of reliable statistical information made proper planning an insurmountable task at independence. The total enrollment in 1988 in grade 12 (Std. 10) was 3020 of which 933 were from the White administration and 2077 from the other 10 ethnic administrations making up about 90% of the population. These figures are for all subjects, this means that the numbers for Maths and Science are more gloomy as these subjects were not compulsory.

The same trend was observed for the number of teachers with sufficient formal qualifications and physical facilities provision for different ethnic groups. It is against this background that reforms were regarded as a matter of urgency despite the fact that most people were skeptical, general acceptance was doubtful and the process of going through the change was quite uncertain and painful at times. It is very important to mention that enrollment for grade 12 has increased to 12880 in 1998 (EMIS Education Statistics -1998) of which 6065 has enrolled for Maths and 4872 for Physical Science. However, the examination results in both subjects are showing that more efforts, thoughts, and resources need to be committed to science education. Hence the European Union funded projects, the In-service Training and Assistance to Namibian Teachers (INSTANT) Project (1992-1996) and the new Mathematics and Science Teacher Extension Program has been introduced to retrain a total of 360 Namibian science teachers as well as to supply some support and coordination at regional level.

Introduction

This presentation has been prepared against this background and is aiming at highlighting the Science Education Reform process in Namibia after independence. The presentation is divided into four themes:

- The importance of an overall educational philosophy, that all understand, that is driving the changes and that of clear planning to achieve the goal
- The curriculum reform that were made in the sciences to implement the change in philosophy, and problems associated with their acceptance and implementation
- The teacher support programmes that were developed to support the changes; their successes and failures and possible reasons for both.
- Effective educational change requires coordinated action on many fronts. In Namibia, there was such action in the education sector.

The Reform Process and Its Guiding Principle

The importance of an overall educational philosophy, that all understand, that is driving the changes and that of clear planning to achieve the goal.

In 1989 an international conference was held at United Nations Institute for Namibia (UNIN) with the main aim of looking at Teacher Education in Namibia. The proceedings identified principles and priorities. Science and mathematics were a priority and a learner-centered and practical approach was needed. This led directly to donor funding being available at a short notice, from the European Union and Denmark. 'Towards Education for All" was published in 1993 with Swedish International Development Agency (SIDA) assistance. It was a development brief for education and training which translated the philosophy developed at UNIN into concrete and implementable policies. The Policy document states clearly the importance of education and development and the fact that these two go hand in hand (p18). Hence the curriculum had to relate to needs in development.

On the other hand, Namibia has always lacked the kind of specific planning details that formed part of the 5-year plans that characterized, for example, the early stages of development of the post-independent education system in other Southern African countries. This is mainly due to lack of reliable statistical information at independence. This meant that while we had a clear idea of what kind of teachers we had to produce, we did not have, and still do not have, a clear idea of how many we should be producing, how many we are producing, or attrition rates.

The curriculum changes that were made in the sciences to implement the change in philosophy, and problems associated with their acceptance and implementation

There has been clear leadership from the top especially from the Ministers who themselves are former teachers and understand the principles and difficulties at a classroom level. They maintain close personal interests in the details of what is happening in the ministries.

A wide and proper consultation was needed between different stakeholders at different levels. Everyone was involved. This was one way of ensuring that everyone in the system, which formerly was a very divisive one, was forced to work together and had some ownership of the product. It led to compromises and the overall curriculum tended to be somewhat conservative and overloaded but it ensured general acceptance.

Although the curriculum reform was in different stages, most activities were run in parallel: - e.g. Revisions at Junior Secondary and Senior secondary overlapped and the reforms started at Junior Secondary level. All reforms were completed within eight years (instead of 12 years) at Grade 1-7 (primary) and Grades 8-12 (secondary). This led to rapid results but to a poor articulation between subject content in primary and in secondary levels, which had to be put right later.

Five Major Changes:

- A major change was that mathematics and physical science became compulsory until Grade 10. In the previous system although compulsory to Grade 9, they were perceived as 'difficult' and very few schools other than those in the former White Administration offered them effectively. This meant that few teachers were qualified to teach these subjects at independence. It is a huge backlog that the country is still trying to address. Much of the effort of one of the Projects, the EU-funded INSTANT (In-Service Training and Assistance to Namibian Teachers) was directed towards rectifying the situation by working with a big number of unqualified teachers to enable them to teach Maths and Science and easing the difficulty of going through change.
- Life Science was introduced as a separate subject at Junior Secondary. Previously it was offered as component together with Physical science to the end of Grade 9. Some aspects of agricultural practices were incorporated into the Life Science.
- An existing package offered by UCLES, the University of Cambridge Examinations Syndicate, the IGCSE (International General Certificate of Education), the international version of the UK local GCSE, was introduced for Grade 11 and 12. In order to try and minimize the extent of the change, two steps were taken to make it as similar and acceptable as possible to the system it replaced, the South African Matric. An advanced version, the Higher IGCSE, paralleling the Higher Grade in Matric, was produced by Cambridge

especially for Namibia. This was accepted by South African Universities as an entry requirement, an important factor in getting it widely accepted by Namibian parents. A large conference was held to sell the package to the Namibian public before its introduction; getting all the parents, commerce and industry on board at an early stage was rightly seen as important.

- Approach of teaching and learning at all phases had to change from the previous teacher oriented to a learner-centered and practical approach.
- English became the new medium of instruction from Junior Secondary and for Maths and science and a few other subjects at senior primary. This had major implication for teaching and learning, as for most Namibians it is a third or a fourth language.

Implications and problems for Maths and Science teaching

As maths and science became compulsory for all learners up to junior secondary and the overall increase in access to schools to most Namibians, there was an urgent need for trained teachers at all levels. The Colleges and the University had to increase their enrollments but could not find suitable candidates who met the requirements. It was also very important for the existing teachers to go through an intensive in-service training programme to enable them to teach using the new philosophy that is of a learner-centered approach.New materials and text-books that have relevance to the Namibian situation and with local examples and practices had to be developed. There was a need for science equipment if we had to teach successfully using the new approach. Teachers needed help at the classroom level for the change to be meaningful. As English is a second or third language to most Namibians its proficiency and its effects on maths and science teaching needs to be investigated, although indications are that it has a bearing on the poor results in other subjects.Other problems that impact on effective teaching of maths and science are over-crowded classes and commitment by both teachers and learners in the classroom as well as lack of parental involvement.

The teacher support programmes that were developed to support the changes; their successes and failures and possible reasons for both.

The greatest need for emergency retraining was identified as among Grade 8-10 teachers, particularly in areas formerly not offering mathematics or science, which are now compulsory. International Volunteer organizations supplied teachers. Increased bursary/loan allocation to science student teachers. However, the low output at school level is making it difficult for tertiary institutions to enroll sufficient numbers of Maths and Science students. Hence, a need for a bridging course.

Lack of suitable equipment was a serious problem. Several hundred small kits that had been developed for rural schools in South Africa, were acquired and training linked to them by both Life Science Project and INSTANT project. In the years, immediately after independence, there was much enthusiasm for change and teachers were very willing to attend retraining workshops, often in their own time. In subsequent years, after the initial euphoria had subsided, teachers were less willing to give up time to training unless it was part of a well-planned and certificated programme that would give them a salary increment.

The two main in-service and curriculum development programmes, the INSTANT project and the Life Science project (Danish funded), supporting grades 8-10 Life Science, (a new subject) pursued broadly similar goals of linked curriculum development, teacher development and materials development. In both cases, the materials included pupils' textbooks and teacher materials. Whereas the Life Science project was responsible fully for the production of learner materials, the role of INSTANT was more in assisting the publishers with editorial advice and author training. Both projects promoted a cascade-training mode based on clusters in the regions that received a degree of support from the regional office but were very largely autonomous and self-motivated. The cascade model involved facilitator training, regional workshops leading to cluster activities and selected (and rather limited) school follow-up.

The INSTANT Project was phased out during 1996, and the Life Science Project in 1999. It is salutary to look around now at the legacy of INSTANT to see what remains and what has disappeared:

- There is evidence in all regions of the paradigm change in classroom activities that INSTANT helped to promote. However, although most teachers acknowledge how they ought to be teaching, the reality is a compromise between the old and new approaches, with, in general the old approaches still very dominant.
- Some parts of the curriculum have been more accessible to the new teaching approach and there are a number of reasons that can be identified that can possibly account for this:
    - o when the topic is entirely new and the new way of teaching is the only one in the teacher's repertoire. An example of this is a section on science materials for Grade 10, which is widely taught in the learner-centered way that the project and the textbook promote. Much of the Life Science work falls into this category.
    - o when the old way of teaching the topic was manifestly poor, leading to a very limited understanding. An example of this is the traditional way of teaching pressure that essentially involved merely a mathematical algorithm. The learner centered, easy-to-understand and cheap-to-administer method promoted by INSTANT, is widely used.
    - o the traditional teaching techniques of certain topics are so deeply ingrained that they are very intractable and resistant to change. Examples are topics that are built round a lot of what used to be called (and still are called in some schoolbooks), scientific laws, such as reflection and refraction.
- There is little evidence in the schools of the teacher materials that INSTANT prepared (though teachers could well have been using them for preparation at home).
- The textbooks are widely used by teachers in lessons. The use of an annotated textbook as teacher materials seems quite widespread. There is a lesson to be learnt here. Such books should contain teaching ideas such as good quality activities and questions and the support of the development of such books could be a very cost-effective form.
- In general, little practical work is done, though there are many noteworthy exceptions to the rule. Some of these (practical work) clearly have a debt to INSTANT but others are more recent BETD (Basic Education Teaching Diploma) graduates.
- Under the Matric system, practical work was almost exclusively of the 'concept practical' type; its main function was to illustrate a concept. The new curriculum tried to introduce the notion of practical skills and along with it, the notion of assessment of practical skills. This has not yet taken root widely. One difficulty is that such a huge variety of ideas for practical work were developed by the INSTANT that teachers have become confused and unable to prioritize. When they do think of practical work, it is usually in terms of concept practicals and this generates the comment (or excuse) that it cannot be done because of lack of equipment.
- The cluster system seems to have a half-life of about a year after the project support has been withdrawn. Some regions are currently building a cluster system into their administrative structure and this may revive cluster activities. The need now is to establish resources for science teachers that these official clusters can access easily.

Effective educational change requires coordinated action on many fronts. In Namibia, there was such action in the following areas:

- New curricula for the whole education system, grade 1-12.
- New curricula in the colleges of Education which produce teachers for grades 1-10 with Basic Education Teaching Diploma; Emergency retraining programmes for serving teachers in Grades 8-12; Support for the new Life Science Programme grades 8-10; General support for Grades 1-4 in the most needy regions.

- Development of new administrative structures and clusters through which the teacher education services, inspection and advisory services could operate.
- An English language project that linked colleges of education with regional advisory services looked at the problem of the change to English as the medium of instruction from Grade 4 upwards substantial changes have not been effected in the following areas.
- Grades 4-7 science and mathematics.
- Teacher education at UNAM. A new BEd (Basic Education Development) curriculum has been introduced but the numbers of students completing cannot meet the demand.

Unfortunately these are key areas of the cycle if underachievement is to be broken. There is substantial evidence that poor mathematics teaching at grades 4-7, is influencing what can be achieved by Grade 10. This in turn influences both the quality and quantity of students entering grade 11 in both science and mathematics.The shortfall in the number of teachers coming from the country's only University compared with demand, means that the teaching force for Grade 11 and 12 is largely expatriate. Most of these bring their own teaching style and lack familiarity with the IGCSE. To counteract this a two-year part-time programme for upgrading Namibian teachers to teach at senior secondary level has just been started with EU support, where it is hoped that 360 Maths, Science and Biology teachers currently teaching at junior secondary and senior secondary, will be able to complete a two-year in-service training course at end of 2003.

Conclusion

There are important lessons to be learnt from the Namibian case. Firstly, reforms will not work if there is no genuine political will and commitment. The educational change in Namibia would have been more painful if there was no support and strong will from the political figures as it has been demonstrated by the Head of State and both ministers of education. This commitment is shown in the high proportion of the budget committed to the education sector, which unfortunately has to address a huge backlog in many areas, especially to make education accessible to many disadvantaged Namibians. Secondly, for any reform to work successfully there should be wide consultation between different stakeholders to ensure acceptance. Especially if we want the output (school leavers) to fit the labour market needs and demands. Thirdly, a coordinated programme is essential to enable the teachers to go through the change with less difficulties, such as the language problem most Namibian teachers had to experience. For a successful implementation of the learner-centered approach, teachers need to be innovative and this should be entrenched in any teacher education programme. This might work if teachers are taken out of isolation and linked to other teachers in a well-managed cluster system, coupled with a very good support system, such as subject advisory teachers at regional level. A good language programme should be included in any programme if effective change has to be observed.

Fourthly, it is also evident from the Namibian experience that it is worthwhile investing in textbook production with a very good teacher guide rather than a variety of teaching materials. It is very important to make use of local materials to ease the burden of the need of expensive science equipment. Training should be attached to material production, if we want to ensure effective as well extensive use. At independence, very few Namibians were trained in science related fields. Skilled labour for fields requiring such skills had to be imported from elsewhere, when the South Africans pulled out at independence. In addition, lack of reliable statistical information made proper planning an insurmountable task at independence.

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Correspondence: C.U. Tjikuua
Chief Education Officer: Education Programme Implementation: Secondary Division
Ministry of Basic Education, Sport and Culture
Private Bag 13186
Windhoek
Namibia
ctjikuua@emis.mec.gov.na
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An African Renaissance in Science Education: a UK-South Africa Partnership

Cynthia Chishimba *Northwest Province, South Africa, Director of PEN*
and
Elizabeth Rasekoala *Ishango House Manchester, UK Director of the Network*

Background

South African President Thabo Mbeki's call to all Africans throughout the world to work together to solve Africa's problems and empower Africa's people has been conceptualised in his vision of an African renaissance. In the fields of science, maths and technology in South Africa, the imperative to deliver this vision is particularly crucial, especially as Chisholm (1991/2:1) claims that 'one of the most profoundly pernicious legacies of apartheid schooling has been the concentration of mathematical and scientific knowledge in the white community'.

Phafogang Education Network (PEN), a Black-led science NGO based in South Africa's North-West Province, and the African-Caribbean Network for Science and Technology (the Network), a Black-led educational charity based in the UK, have taken up the challenge of working in partnership to deliver the President's vision. Both organisations have a unique leadership role in the their respective countries, as they are the only organisations solely focused on addressing the under-representation, under-achievement and under-participation of Blacks in Science, Engineering and Technology (SET) in both societies, where the challenges and patterns of disadvantage and inequality are very similar.

The links between the Network and PEN have been continuous since 1998, thanks to the support of the South African Government Department for Arts, Culture, Science and Technology (DACST) and the National Research Foundation (NRF).

Achievements to date

The Network and PEN have supported the delivery of initiatives at national and provincial levels. Activities have included:

- South Africa's First Year of Science and Technology 1998: activities in the North-West Province benefited 70,000 students, teachers and parents throughout the year.
- South Africa's First National Science and Technology Camp for Girls, Hilton College, 9-17 July 1999; funded by DACST, this was a high-profile initiative, launched by the National Minister for Arts, Culture, Science and Technology, involving sixty-three girls (age eleven to sixteen) and eighteen maths/ science teachers (two teachers and seven girls per province were chosen to participate).
- South Africa's First National SET Week (20-25 March 2000); this inaugural SET Week was targeted at three provinces - the North-West, Northern Cape and Western Cape - and

featured a variety of interactive activities, exhibitions and hands-on displays to engage everyone's interest in, and awareness of, the impact of science in their everyday lives. The national media were effectively used to popularise the aims and objectives of the week.

Activities in the North-West Province

Within the North-West Province, the partnership's activities have been given political support by the Member of the Executive Council (MEC) for Education and the Premier of the Province. This has also involved strategic working partnerships with the Advisory Support Services for Schools, and links with the two universities in the province, the University of the North-West and Potchefstroom University. Links have also been developed with the local media, and leaders and chiefs throughout the province have also lent their support.

The core activities of the partnership in the province have involved the provision of additional support for students in maths, science and technology, in-service training (INSET), and support for parents, to enable them to effectively support their children's educational attainment. A key challenge to the work in the province is its largely rural geography (sixty per cent of population live in rural areas). The activities delivered by the partnership in the province include:

- Marang Science Clubs - after-school study support programmes in maths, science, technology, physics, chemistry, biology and other related subjects. Thus far, these programmes have been delivered on Saturday mornings to Grade 10-12 students. Plans are under way to extend this provision to weekday sessions, after school hours, and for students from Grades 7 to 12.

We've only just begun...

While the partnership has achieved a great deal in its short period of existence, they believe that they are very much at the beginning of an exciting but challenging journey, and that there is much more to come, and much more that we want to achieve for black youth in South Africa and the U.K.

This dynamic partnership has been led, driven and sustained through the commitment of, as they like to call themselves, "the two fat ladies in science', Liz Rasekoala, the Director of the Network and Cynthia Chishimba, the Director of PEN. The British Council's support for this partnership through its sponsorship of Mrs. Chishimba's U.K Study Tour in the UK in summer 2000 has enabled the recruitment of more UK-based partners to support the delivery of its programmes in the UK and in South Africa. The teachers, students and parents who participate in, and benefit from, the activities of the Network in the UK have been empowered through Mrs. Chishimba's visit, and have learnt from her experiences in terms of dealing with challenges in South Africa.

This is what makes this partnership unique, empowering and innovative, as it is about learning and sharing across both countries. It is a level playing field where no one feels patronised, exploited or dominated, and brings Africans together within a constructive and positive framework.

Science Education in the School Curriculum: its Relation with Technology

World Bank/British Council Report

In the 1960s in England and Wales, as in a number of other industrialised countries, there was quite a massive revision of the teaching of science in schools. The Nuffield Foundation provided hitherto undreamed of financial support for a succession of projects to develop materials and curricula for chemistry, physics and biology (for the "O" and "A" level examinations), for primary science, a combined science for lower secondary, a secondary science course for the "less able", etc.

Although the perspectives of the nature of science that generally informed these projects were not as "pure" or abstract as those that underpinned the corresponding National Science Foundation projects on the other side of the Atlantic, they did establish a strongly conceptual type of science as the science of school classrooms. Indeed, it was a chance for school science to catch up with where university science had been moving in its more rapid recovery and boom period in the 1950s. This sort of ideology of pure science had been established much earlier as the dominant influence in British science education. It is significant to note that these Nuffield reforms of science curricula were underway before the emergence of the comprehensive schools and the possibility that the needs of their quite different clientele of pupils might seriously question this influence.

The Nuffield reformers certainly intended the science at school to be stimulating and attractive to the pupils in schools, but clearly it was also to be the means of preparing and selecting the next generations of students for scientific higher education who, in turn would become the nation's future professional scientists. The massive expansion of post-graduate study and research in university science departments since World War II re-enforced the pure and conceptual emphases in these school science courses. The model for the learning pupil was the research scientist discovering new knowledge to unravel phenomena, and then inventing concepts to accommodate the new knowledge and to describe and explain the phenomena.

Learning chemistry for example, became less the learning of a collection of factual properties of elements and compounds and of the acquisition of practical skills, and more the learning of conceptual ideas like bond types and electronic arrangements and their application to phenomena via kinetic and other molecular-scale models of matter.

Primary science was initially defined rather openly in terms of discovery and enquiry and then more specifically as processes like observing, classifying, measuring, hypothesising, predicting and problem solving. These were seen to be tools of trade of the scientist - a sort of step-by-step scientific method.

Compared with the current interest in the relevance of science to pupils' own lives, these earlier developments (the mainsprings of science education at least until the GCSE and now the looming National Curriculum) can be described as giving more attention to inducting learners into the disciplines of the sciences than to making them aware of their applications in society or in their lives outside of school.

Nevertheless, with support from the Schools Council and other sources, there were, in the 1970s and 1980s, a number of projects in the science field that used other contexts of a more applied variety to produce science materials for teachers to use. Most of this material was of a modular or exemplary nature rather than constituting a framework for teaching a science course as a whole.

Two distinct approaches to the application of science have been used in these projects. The first is to see the modular material as enabling the basic study of the science content to be extended into applications that illustrate the significance of particular concepts for science topics in British society and industry. The Science and Technology in Society project (SATIS) has produced many short modules for study of this type.

The second approach chooses an application of science and develops modular material that allows for more substantive teaching of the science that relates to this applied science context. The Working with Science project was an example of this approach and other modules of this sort have been developed for use in chemistry, physics and biology.

There is a substantial difference in terms of a technology dimension between these two approaches. It can be summed up by saying that science plus applications is not the same as the science of an application. The former tends to have the application of science as an optional extra to the essential learning, which is the science itself. The latter treats the application as the serious topic of study, and in doing so can quite radically restructure the science content to be learnt, its sequence and its relationships of importance.

The second approach has also been the basis for the development of two courses of study which take the interactions between science and society as their areas of study. These whole courses, while remaining marginal to the great bulk of pupils, have provided useful examples of the sorts of learning about the science/society interface to which greater significance is now being afforded under the National Criteria (for the GCSE) referred to earlier and in the National Curriculum. The pupils who have studied Science and Society, or Science in a Social Context (SISCON) have had a holistic experience of the application of science or of technology in British social and economic life - a learning experience that should increasingly now become a component of all pupils' studies in science or in technology more generally. The SISCON course encourages a more critical awareness in its approach to learning about science in society, - an aspect that is more central and explicitly in the attainment targets for Design and Technology in the National Curriculum than it is in the attainment targets for Science.

In the development of actual science courses for the GCSE, it has been left to syllabus and materials developers to encourage individual teachers to choose contexts and approaches to learning that would make the links between the science content and its application clear. The new Salters Chemistry course (from York University), by providing a set of materials for three years of teaching, is probably the best indicator yet of the outer edge of the technology dimension of science education. Its materials encourage teachers:

1. to start with material and phenomena familiar to 13 - 16 year olds from their own experiences or from TV, books, etc.

2. to include industrial, technological, economic, and social implications of chemistry so they are central to its study.

It is, however, a course of study that is still constructed to teach the criteria laid down for the chemistry content for GCSE. In doing so it does teach chemistry in application, and how chemistry influences societal and personal life. Furthermore, it encourages learning about examples of chemistry in society. It is not, however, a course to develop learners' chemical capability in the sense of using chemical and other knowledge and skills to solve real life problems.

From 1990 onwards, pupils in England and Wales will be taught science under the statutory orders for this core subject of the National Curricula. These statutory orders are based on the Report of the Working Group for Science but do differ in several significant ways from it.

One of these is the omission of the rationale for the teaching and learning of science throughout all the years of compulsory schooling. The Working Group's rationale was based on (a) the nature of science itself, (b) the technological nature of society now and in the future, (c) the benefits to the individual learner, and (d)how learning in science occurs.

The second and third difference relate directly to the interests of this case study. Communication and Action were two learning areas in science education that the Working Group highlighted as novel and important ones which should be identified by their own attainment targets. An obvious reason for this distinction is that either of these have been generally recognised hitherto as objectives or outcomes of science education. The statutory orders have blurred these distinctions by subsuming Communication into the first broad attainment target of Exploration of Science, and by subsuming Action into the sixteen Knowledge and Understanding specific attainment targets.

Consideration of the detailed statements of attainment enables some sense to be gained of the technology dimension of science the new National Curriculum is likely to encourage.

Most of the specific references to communication in the attainment targets for Exploration of Science seem to be to skills and tasks that are within the community and culture of science but some are aimed at societal aspects of science, for example, describe investigations in the form of ordered prose, using a limited technical vocabulary and prepare and deliver a report matched to an audience which incorporates background material from a variety of sources.

Under the Knowledge and Understanding topic headings, there are a number of examples in each of their attainment targets (ATs) that make clear that pupils are to acquire knowledge and understanding of how science is a basis of a number of important applications and technologies in society:

- *be able to give a basic explanation and evaluation of the impact of life supporting technology, e.g.incubators ,pace makers, and kidney machines, in improving and sustaining the quality of life (AT 3: Processes of Life)*
- *be able to describe cloning methods and their use in agriculture (AT 4: Genetics and Evolution).*
- *be able to explain how electricity is distributed on a national scale (AT 11: Electricity and Magnetism).*

There is much less in the attainment statements to encourage actual practical capability in relation to the wide range of scientific knowledge that is to be learnt. Nor is there a sense of a progression of these practical skills. Under AT 11: Electricity and Magnetism pupils are to be able to construct simple electrical circuits as the fourth level of attainment (out of 10). This skill is not developed any further in the statements for the six higher levels although another practical capability, be able to measure and cost domestic electrical energy consumption by obtaining the electric meter readings does appear at level 6.

NEWS IN BRIEF

IICBA's Secondary Science and French language Primary School Electronic Libraries

The purpose of the Electronic Libraries in these basic secondary school subjects is to provide interactive and purposeful materials to secondary and primary school teachers, teacher trainers, curriculum developers and supervisors to improve the teaching and learning of the subjects in the secondary schools of Africa. With this purpose in mind, IICBA adapted teaching/learning materials available and developed new ones that suit the African secondary school situations and realities. The libraries consist of:

- Articles and abstracts
- Lesson plans
- A teacher training guide
- Test questions
- Questions asked by teachers

The secondary school Science Library as well as the primary Maths and Science in French, Arabic, and Portuguese will be available in July, 2001.

Effective Schools in Science and Mathematics:IEA's Third International Mathematics and Science Study

Effective Schools in Science and Mathematics presents analyses of the TIMSS 1995 eighth grade data aimed at helping understand what makes some schools more effective than others. The results show that classroom-related variables are related to average school achievement even after adjusting for the home background of the students in the school. However the strong relationship that persists between the average level of home background and adjusted student achievement also serves as a reminder that, in many countries, home background, schooling, and student achievement are closely intertwined, and that teasing out the influences of the various contributing factors remains a major challenge. The complete report is available online in PDF format through the International Study Center.
(http://isc.bc.edu/timss1995i/effective_schools.html)

GLOBE: Global Learning and Observation to Benefit the Environment

<http://www.globe.gov>

GLOBE is a worldwide network of students, teachers and scientists working together to study and understand the global environment. Students share environmental science data worldwide with one another through the GLOBE web-site and by doing so develop awareness, respect and appreciation for one another's cultures and environmental habitats.

Meeting with Norwegian Ministry of Foreign Affairs and NORAD

IICBA participated in a very useful meeting at UNESCO Headquarters, Paris, in January 2001. IICBA's main focus was expansion of the Multigrade Programme which has been pioneered in Ethiopia. It is hoped that the Norwegians will provide support to allow the programme to expand to several other countries in Sub-Saharan Africa.

Association of African Universities (AAU) Conference, Nairobi, February 2001

The Association of African Universities held its annual conference in Nairobi. Major outcomes of the meeting, which was attended by the majority of university vice-chancellors in Africa, included:

- the move towards greater utilization of information and communication technologies (ICTs) in Africa's universities;
- greater attention to the improvement of the number and position of women enrolled at university level;
- focus on HIV/AIDS at universities.

Kampala Workshop on Information and Communication Technology (ICT) Use in Education, March 2001

IICBA and the UNESCO Information and Communications Section held a workshop in Kampala in March 2001 to share information and experiences on how ICTs are being used for educational purposes in East and Southern Africa. Uganda itself has done some important pioneering work by establishing a rural telecentre in Nakaseke and in establishing internet and ICT use in teachers' colleges and secondary schools. UNESCO had helped to develop a virtual reality teaching module on hygiene based at Nakaseke. Two private companies, Multichoice and World Space, provided demonstrations of their new technologies. Multichoice is able to offer internet access through small satellite dishes, and had already done so in a number of Southern African countries. However the governments concerned had to agree to this. World Space is able to download internet materials through their satellite radios. However this is in its infancy.

Survey

Please take a few minutes to fill out this survey, which is key to helping us assess the usefulness and utility of this newsletter as well as to solicit ideas and articles for newsletters in the future.

1. How relevant are the articles contained in this newsletter to your work or the work of educators in your country?

1 2 3 4 5

Little Relevance ... High Relevance

2. If you answered 3 or above, what did you find most useful about the newsletter? If you answered below 3, how can this newsletter be geared more towards your needs?

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3. How easy/difficult did you find this newsletter to read? Do you have any suggestions on how to make the newsletter more accessible to educators?

1 2 3 4 5

Easy to Read ... Difficult to Read

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4. How many people read this newsletter in your office? Does your office circulate it to other educational institutions?

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5. Do you have any ideas for articles that you would like to see this newsletter feature in the future?

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If you would like to write an article for our newsletter, please e-mail your thoughts to info@unesco-iicba.org at the International Institute for Capacity Building in Africa.

UNESCO-IICBA
P.O.Box 2305
Addis Ababa, Ethiopia Africa
Tele: (251) -1-557587
Fax: (251) -1-557585
Email: info@unesco-iicba.org
Web site http://www.unesco-iicba.org