MAJOR ELEMENTS OF SCIENCE AND TECHNOLOGY EDUCATION FOR ALL IN AFRICA: VIEWS FROM BOTSWANA

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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,). 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. 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 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, and
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 outmost 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 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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