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Science in the Secondary Schools of Tanzania

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SCIENCE IN THE SECONDARY SCHOOLS OF TANZANIA

by

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INTRODUCTION

Secondary school science education in Tanzania appears to be in a deteriorating stage. Recent developments show that secondary school students are turning away from science and their examination results have been declining steadily over the last decade. Science teachers are leaving the classroom in alarming numbers to accept positions in business and industry and are being replaced frequently by unqualified or ill-trained teachers. Teacher training programs are not effective for more positive science learning.

This project paper tries to discuss the extent to which some of these trends, as mentioned above, as they appear in Tanzania secondary schools. Most of the literature in this study is the result of library research and experiences of the author and other teachers, both as students and science educators.

The paper has three parts. Part one deals with an overall definition of the discipline of science education, which also includes goals, and current practice in science education. Science as inquiry has also been discussed, both on the part of teachers and students. The second part deals with the historical development of science education in Tanzania from the period long before independence

(1961), when traditional science education was emphasized, to contemporary science education. Various innovations and adaptations of science curriculum are included, with their respective constraints. Part three highlights some recommendations on how science education in Tanzania secondary schools can be improved, bearing in mind the constraints existing of which some of them are difficult to resolve. The area which has been dealt with in detail is the teacher training program in the sciences, with emphasis on inquiry, as a method of effective science education. Suggestions have been made for inquiry approaches. Part three is the conclusion.

This project paper is anticipated to be used as a suggestive document to the Ministry of Education in Tanzania, and particularly in teacher training institutes.

DEFINING THE DISCIPLINE OF SCIENCE EDUCATION

Recently, scientists and educators have written about the discipline of science education without elaborating on the parameters of such a discipline and without defining the meaning of such a designation.

Too often science education is thought to be limited to concern for the science that is taught in K-12 schools and/or colleges and universities. Sometimes it is used to emphasize science teacher education--both the professional programs for preservice and inservice teachers and the research associated with such programs. At times science education is viewed as an attempt to help students learn science.

Many of these definitions are appropriate for a given setting or situation. However, they do not provide much insight beyond administrative or teaching situations. Perhaps such definitions of an early discipline can be visualized through practice until an information base develops. A certain maturity is required and certain information is needed for constructing definitions and models from which practice can emerge. Science education may be at such a point.

The goals of science education at the secondary level are in a period of major transition. A National Science

Teachers Association (NSTA) working paper, entitled Science Education: Accomplishments and Needs, identified several new goals for science education for the 80's. An analysis of the paper (Tager, 1981), revealed general agreement among the leadership of five groups of science educators that an increased focus upon science and society or science in society was needed. Harns and the project synthesis research team reported that a science and society focus is basic if K-12 science teaching is to reach a more desired state (Harns and Yager, 1981). Several college courses have been developed with such an emphasis on the inter-relationships between science and society.

This new goal may provide a major justification for the study of science in K-12 settings and general education science requirements in colleges.

The authors of the NSTA Accomplishments and Needs paper see the science society interphase as the proper setting for science education for the 80's.

Defining the discipline of science education to be the study of science-society interphase removes the restriction that science education is a school or collegiate program. At the same time, it does not exclude such settings as places that the interphase may be effectively considered. Such a designation provides parameters for research efforts, curriculum planning, and educational programs.

Science education is defined then, as the discipline concerned with the study of the interaction of science and society, that is, the study of the impact of science upon society as well as the impact of society upon science. Their interdependence becomes a reality and the interlocking concept for the discipline. Research in science education centers upon this interphase.

The vehicle for science education is often a school or college classroom or laboratory. However, with a broader definition the work of the science educator is not restricted to such places. This definition of science education also includes the relationship of research, curriculum and instruction and teaching approach. It provides a rationale and a coherence that is often missing with more restrictive definitions.

Such a definition of science education gives it a primary role in today's world. Defining science as, "The discipline concerned with the study of the interaction of science and society," provides clear justification for science education by making it clear that science education is a vital link to the future of mankind.

Goals of Science Education

Today's science programs largely reflect goals which began to emerge by consensus a quarter century ago. It is difficult to see much difference between the science

classrooms of today and those of the mid-sixties. The consensus on science education goals which began to emerge in the fifties has not been replaced by a new consensus; the old consensus still underlies most current educational decisions and policies.

A relevant question, then is, "Are the science education goals espoused and used to guide educational practice during the fifties and sixties the ones which should guide practice as we have entered the eighties?" The former goals are no longer adequate and a new consensus is needed for a new era. The world has changed since the sixties, and the schools should be responsive to the society they now serve. It is time for a new consensus on science education goals, a consensus which reflects the "real world" of today and the problems our students will face tomorrow.

In the fifties science instruction in the schools was important for producing the next generation of scientists and engineers and for giving other future citizens an understanding of science that would cause them to vote in support of continued scientific research. The science education of the era was a reflection of the times. Partly in response to the view that science was important for its own sake and that positive benefits would automatically accrue from its pursuit, and partially from a reaction to past practice in the schools, science education goals for

the fifties emphasized science as an intellectual enterprise to be vocationally pursued by an educated elite and supported by a citizenry who appreciated and understood, at least in a broad sense, what it was all about.

In this context, it is not surprising that the processes of science would be emphasized. To understand science was to understand the means by which it proceeds, its modes of inquiry. Science is not just a body of knowledge but a means by which this knowledge is acquired. The nature of science is such that the body of knowledge changes rapidly; the modes of inquiry by which it proceeds are more permanent and their understanding is essential to the education of citizens. A similar argument often was made for emphasizing the structure of the discipline. The broad concepts were more important and more permanent. These concepts were the structure to which other details could be attached. It was an era of emphasis upon theoretical science for science's sake, with a concomitant rejection of scientific applications and technology as instructional topics. The goal became understanding science as a field of disciplined inquiry.

In the eighties, students face a different world. It is one dominated by a multiplicity of science and technology-related societal issues. These issues were not

unknown in the fifties, of course, but their current importance is of a different order of magnitude.

The education of a student of the eighties is not complete without some understanding of its scientific basis, its relationship to societal change, and its many applications.

A significant difference between the world of the fifties and the world of the eighties is reflected in the need to redefine certain problems.

In summary as we are in the eighties we must recognize that the world and its problems cannot be understood, independent of a grasp of scientific and technological matters. "The impact of science and technology on humankind and the society, is becoming the major source of contemporary change" (Brzezinski, 1970).

Implications for Educational Goals

Granted that the world of today is different from the world of the fifties, the question of the implications of the differences for the goals of science education remains. To what extent are the science educational goals of the fifties still relevant today, and to what extent do they take a new dimension for students of the eighties? Obviously, many of the science education goals of the fifties are still valid today (although in almost all cases

we would find some shifts in relative importance), while in other cases, specific goals of the fifties are obsolete.

For example, one viewpoint of the fifties was that science should be taught as process as well as product, i.e., students should have opportunities to experience scientific inquiry as well as learning the body of knowledge which inquiry has produced.

One area where goals may need to be broadened is problem solving. In science instruction, problem solving should not be limited just to the solving of research problems in the various specific science disciplines. Problem solving in the broader sense involves decisions having to do with the applications of science in the "real world". It is not just a matter of solving problems which have a specific answer, but choosing from among all alternatives, none of which are perfect. Choices have to be made which will optimize beneficial outcomes and reduce negative side effects. It cannot be expected that students who learn problem solving in a narrow sense within a sharply defined academic area will be able to transfer these problem-solving abilities to new situations which require not only a different content but a different mode of problem solving.

The largest change required in the science education goals of the eighties is more attention to understanding the technological applications of science and their impact

upon society and the people of the world. Under the consensus of the fifties science content was selected almost exclusively for its contribution to understanding the nature and structure of a particular discipline. While that goal is still important, it must move over to make room for other criteria for selecting the science content to be included in science courses. Much more attention must be given to the relevance of scientific knowledge to a wide range of societal issues, including world food supplies, energy sources, national security, and the human impact of technological change.

The question of what goals should be pursued is one that deserves widespread debate. We have assumed for too long that the goals we have been pursuing are adequate. Redefinition is in order and it can only come about through the involvement of science teachers, other educators, scientists and technologists, and the public as a whole. The time honored question of "What knowledge of most worth?" needs urgent attention anew.

Current School Practice

Science education goals are divided into four categories: personal needs, societal issues, academic preparation, and careers preparation (Harns, 1981). Personal needs refer to those goals pertaining to individuals' preparation to use science in their own lives

and to live in an increasingly technological world. Societal issues refer to those goals pertaining to preparing citizens who are informed and able to deal responsibly with science-related societal issues. The third goal of academic preparation pertains to acquiring academic knowledge of science, in other words, science knowledge, per se, independent of its applications. The fourth goal of career preparation pertains to acquiring knowledge of the nature and scope of scientific and technological careers and utilization of this knowledge in making career decisions.

However science teaching in schools is focused almost exclusively upon the third goal, that of academic preparation. In other words, it is clear that the goals which are becoming increasingly important in the world of the eighties are not being pursued vigorously in that world's schools. In secondary schools the goal of academic preparation is actively pursued in the main by those students preparing for college. No science seems to be of major importance for general education of all students.

Inquiry and the Science Teacher

The notion of inquiry has been central to science education in the last 20 years. Until recently, however, the evidence regarding the effects of various aspects of inquiry on students' learning and attitudes has been

equivocal. The use of inquiry for example in Tanzania secondary school has been rare and many teachers believe that inquiry is possible only with bright students.

Science teachers have the responsibility of presenting science as inquiry and of matching the level of inquiry to the capabilities and needs of their students. Specific measures should be taken to provide these teachers with the essential understanding of the nature of inquiry.

This line of thinking is shared by other science educators. For example, Welch et al. (1981) observed that:

There appears to be a discrepancy between existing general statements about the importance of inquiry and the attention given to it in practice. Although teachers made positive statements about the value of inquiry, they often felt more responsibility for teaching facts, things which show up in tests ... A major problem in prompting inquiry was encountered in the preparation of science teachers. Many teachers are ill-prepared, in their own eyes and in the eyes of other to guide students in inquiry learning and over one third feel they receive inadequate support for such teaching.

Presently, the notion of inquiry causes a great deal of confusion among teachers and this may well be a main reason for teachers not presenting science as inquiry.

The Nature of Inquiry

Schwab's (1962) conception of the teaching of science as inquiry is a good starting point for the discussion.

The phrase, the teaching of science as inquiry, is ambiguous. It means, first, a process of teaching and learning which is itself an inquiry, 'teaching as inquiry'. It means second, instruction in which science is seen as a process of inquiry, 'science as inquiry' (p. 65).

This distinction between "science as inquiry" and "teaching-learning by inquiry" is an important one. The first defines the substantive focus of the classroom, what is taught, and hopefully learned. The second refers to how teaching and learning are executed, the nature of classroom transactions, and the inquiry skills that will be practiced. Each of these two aspects of inquiry carries important "metal lessons". Teaching and learning by inquiry opens opportunities of getting first-hand experience in doing science and, in addition, to developing inquiry skills, such as the abilities to identify and define a problem, to formulate a hypothesis, to design an experiment, and to collect, analyze, and interpret data. It also teaches important attitudinal "metal lessons" such as curiosity, perseverance, experiencing failure, dealing with doubts, etc.

The teaching of science as inquiry, on the other hand, in addition to transmitting concepts, principles, and facts, has the responsibility of conveying a realistic image of science and to nature. For example, students should realize that:

Scientific knowledge is always open to change and revision ... Scientific knowledge is not to be seen as the final truth about the world; rather it is

the most adequate account of the world available at a given time ... (Connelly et al., 1977, p. 7).

Why is this view of science so important to understand?

One argument ... relates to the rapid change at which scientific knowledge is revised. Students who ... view science as a collection of facts, subject to verification and proof that constitutes a body of literal truth about the world ... will eventually encounter revised versions of scientific knowledge ... They will be confused by the disappearance of the facts that were taught, for they have no basis for understanding the change. They are likely to become cynical about the scientific enterprise and will certainly regard what they have learned as a little value ... Also, as future citizens they will be unequipped to follow scientific debates concerning public issues (Connelly et al., 1977, pp. 7-8).

Once we accept the distinction between science as inquiry and teaching and learning by inquiry we are in a position to understand why the notion of inquiry has caused so much confusion. While there may be good reasons to suggest that many of the problem-solving assignments and discovery learning exercises are beyond the capabilities of many students and teachers and therefore, perhaps, many students may profit from a more structured presentation, there is no basis for suggesting that only the more talented students will enjoy the privilege of learning what science really is.

Of the two components--science as inquiry and the activity of inquiring--it is the former which should be given first priority as the objective of science teaching (Schwab, 1962, p. 66).

The essence of teaching science as inquiry would be to show some of the conclusions of science in the framework of the way they arise and are tested. This would mean to tell the student about the problems posed and the experiments performed, to indicate the data thus found and to follow the interpretation by which these data were converted into scientific knowledge (Schwab, 1963, p. 40).

The Teaching of Science as Inquiry

Since teachers have a major responsibility for transmitting the image of science as inquiry to students, it is necessary to ascertain that they themselves have an adequate understanding of this notion.

What is the image of science as inquiry held by teachers? Most teachers are not aware of or confuse the distinction between the concept of science as inquiry on the one hand, and the process of teaching science by inquiry on the other. Very few teachers who know that one can teach science as inquiry by presenting a lecture using a narrative of inquiry, and that one may not teach science as inquiry by putting students through laboratory exercises which are merely aimed at finding the right answers by following a set series of steps.

HISTORICAL DEVELOPMENT OF SCIENCE EDUCATION IN TANZANIA

Science education in Tanzania started way back in the 1880's and even before that, when there was what could be called traditional education. In this type of education it was more centralized among small tribal groups where children and young people were trained the values of their own society or clan. The sciences taught then, were aspects like construction of simple tools, the learning of the important medicinal herbs and their methods of treatment, farming techniques and time estimation by observation of the galaxy, sun, moon and stars. This type of education was quite sufficient for the small communities.

With the invasion of the missionaries and colonial powers, modern education was introduced which was more formalized in the sense that pupils were to go to schools established by these people. The main purpose of education by then, was to cater for the interests of the missionaries to spread their religion, and for the colonials, to train lower cadres for government services. This type of education did not have much to do with the development of the sciences as well as other studies in the humanities.

Only a few places where missionaries established hospitals, and vocational schools was science taught. Then it was taught as basic practical information to help the concerned do the helping jobs of these areas.

Sometime in the mid thirties, formal secondary schools were established, again by the missionaries to a large extent, and partly by the government. Again science was not their main interest; except for the basic biological concepts, and mathematics. This can be evidenced by looking at the number of graduates by then, who usually graduated from seminaries (theological schools) where they mainly studied theology, philosophy and other subjects such as history, geography, English and Swahili.

Major changes took place in the early fifties after the second world war, which resulted in modern industrialization. Subjects such as physics, chemistry, biology and mathematics were introduced. Very few students opted for these courses for various reasons, including lack of science teachers. Most of them had come from overseas. There were no Tanzanian science teachers by then. If there were, they were very inadequately trained.

There were other schools for minority groups like Asians and whites. In these schools science was taught.

In the sixties, major educational changes had to take place, especially after independence (1961). There have been changes in the overall educational system, and various

trials and errors in the science curriculum in both primary and secondary schools. These changes were the result of earlier complaints from African and Asian parents, as well as from Tanzanian African educators. These complaints grew out of dissatisfaction with poor performance of African and Asian students in the examinations at the end of the primary and secondary schooling.

As a result of this examination grievance regarding the high rate of failure of African and Asian students, serious curriculum development began to take shape. After independence the Ministry of Education attempted to develop a more concrete curriculum in the sciences. The period post independence has produced various innovations in both primary and secondary school levels. More emphasis has been put on mathematics and sciences. The new secondary science curriculum operating by then in Tanzanian schools had been directly or indirectly influenced by science curriculum developments and innovations from the United States and Britain.

In the mid sixties education in Tanzania with the declaration of education for self reliance (1967) had to develop a new outlook. One of the widely known changes in science education was its gradual displacement of student centered curriculums by the learner-centered curriculum. Tanzania by implementing this change, and science education had gradually developed so that the curriculum had to be

relevant, challenging and interesting to secondary students.

There are three commonly taught sciences in Tanzanian secondary schools: Biology, Chemistry, and Physics. Science innovations that were taking place in other developed countries had an impact in Tanzania. The Nuffield Science Teaching Project (NSTP) which started its work in England in 1962, was adapted in Tanzania secondary schools. While Nuffield courses were being adapted in the Tanzanian secondary schools, East African science educators were busy creating their own science innovation that reflected what they thought to be relevant to East African learners. This innovation is widely known as the East African School Science Project, shortened to School Science Project (SSP).

The SSP started in 1965. There were three SSP courses: SSP Biology, SSP Chemistry and SSP Physics. All of them were influenced directly or indirectly by new science developments in the United States. In 1968, fourteen secondary schools in Tanzania were experimenting with Nuffield Physics. In all three East African countries it was reported in 1970, that 12,000 students in about sixty-five secondary schools with 110 teachers (the majority being expatriates) were involved in SSP Physics. It was anticipated that candidates would be able to take SSP 0-level examinations for the first time in 1970.

After two years of the School Science Project experimentation, Tanzania withdrew in 1970 from the project because of political tensions between the two countries (Kenya and Uganda).

SSP programs in Tanzania had its problems which hindered full implementation of the sciences. These problems included the following.

1. Examinations and curriculum.
2. Teacher orientation, training and retention.
3. Science equipment.
4. Attitude towards the science course.

These problems are not only unique with SSP programs, but with all other science curriculums implemented later. The problems will be discussed later in this paper.

State of Secondary Education in Maths and Science

For nearly two and a half decades, since Tanzania became independent, science enrollments in secondary schools have been increasing gradually, but not at an encouraging rate. Students are unmotivated to study science in schools despite the government's emphasis in the sciences. Mathematics is a compulsory subject throughout primary and secondary education, but show an overall decline in achievement. For both science and mathematics courses there is a growing shortage of teachers. If a reasonable degree of scientific and technological literacy

is an expected outcome of secondary education, it is not being achieved.

There are sex differences in the mathematics and science course work in secondary school students. Males take more science and mathematics than females. The proportion of males in vocational programs is increasing while the proportion of females is becoming less. Enrollments in school subjects are influenced by student attitudes and school requirements. Students do not particularly like science courses and this dislike is acquired early. By the end of form 2 nearly half of the students feel they would not like to take science. The main reason for not liking science is that there are too many terms to memorize. The most frequent question raised by students in mathematics and science is: "How am I going to use this stuff?" The usual answer: "You will need it to pass the next course." The encouraging note is that students like science when they learn about it outside of school, at museums, field trips, etc.

There are a number of factors that appear to have a negative effect on the achievement of the highest possible quality in Tanzania science education:

- Sex stereotyping in regard to science and mathematics achievement.
- Automatic grade promotion.
- Breakdown in class discipline.

- Unfavorable study environments (particularly day schools).
- Lack of sufficient homework.
- Unclear educational goals and policies (lack of definition).
- Teacher disillusionment.

To revitalize the quality of school science and mathematics education in Tanzania will require a consideration of social and cultural conditions impacting schools, as well as the revitalization of curricula and instructional practices.

Some Constraints Influencing Science Education in Tanzania

Tanzania lacks national goals, public policies or rather a definition of policy (education for self-reliance) to focus discussion and debate in the reconstruction of science and mathematics education. As a basis for policy, the need for a high level of scientific, technological literacy is most often identified. If this is to be a goal of science and mathematics education at the secondary levels, parents, teachers, and school administrators must first recognize its significance.

The school curriculum. Doubts exist as to whether the commonly offered science courses in secondary schools are of value to the general citizen, at least in their present form. In the Tanzanian Educational System (ESR),

despite its emphasis in relating school curriculum and real life, the main objectives in schools are to instruct learners to pass national examinations, and more often not preparing students for real life. Hence examinations carry heavy weight and cannot be changed. The nature of instruction always directs itself in the nature of evaluation of examinations. Many approaches to affective learning are avoided due to this constraint. Students regard upper level physics, biology and chemistry courses pre-professional subjects for those to wish to become engineers, or scientists. For science subjects the issue is: What knowledge acquired in the past 100 years from various science disciplines should be selected to provide instruction for a secondary school course? Not only should this knowledge be significantly valid, but should also satisfy the requirements of cultural validity.

Science equipment. Sciences are laboratory-oriented, and students must have equipment and materials in order to do the experiments through which they are guided to learn. It has been very difficult to implement the teaching of the sciences effectively without the availability of basic science equipment. One source of this problem has been that since its inception the science curriculum required the use of too much expensive equipment which had to be imported from overseas. Unfortunately, the high cost of imported science equipment to secondary schools in Tanzania

prevented some schools from acquiring equipment necessary for the execution of the experiments. However because of this high cost of imported equipment, Tanzania through its own self-reliant initiatives, is prompted to produce locally inexpensive scientific equipment to meet the need of secondary schools of Tanzania. As a result of this initiative the center for curriculum development is charged with the training of teachers to be able to produce improvised teaching equipment. The basic science equipment is not available. This problem is most serious in rural and private secondary schools.

Textbooks. The availability of science textbooks poses a big problem in Tanzania secondary schools. Textbooks are very few. One textbook is shared by five to six students if the school is lucky to have the books; otherwise the teacher will be the sole person with a textbook. This necessitates teachers to dictate notes to students and hence encourages rote learning. Some books are out of date, and some especially in the biological science give illustrations and examples (plants) of organisms or habitats which students are not familiar with. Reference books are almost non-existent. Most school libraries are ill-equipped with up to date reference books. Journals where recent discoveries and scientific development are reported are a dream. All these drawbacks affect science education in Tanzania.

Supply and qualification of teachers. The shortage of qualified science teachers for Tanzania schools has become a matter of serious concern. Although since independence the number of teachers in biology, chemistry, and physics has increased, at the same time, the ratio of student increase and teacher output is incompatible, thus pressure to teach for examinations. Secondly, of those trained to teach science, a decreasing number go into teaching. Many choose business or industry where they can get better pay and better working conditions.

The academic preparation of science teachers, particularly in methods of teaching science has become an unrecognized responsibility of departments in colleges and at the university.

Most teachers in Tanzania have taught for several years, and their training has been didactic, talk and chalk approach which frequently results to rote learning. When the discovery-inquiry approach was introduced in Tanzania only a portion of the teachers had been trained through inservice courses. These inservice courses have assisted some teachers in making the transitions in teaching styles, but they have not been wholly effective because many teachers have not grasped and/or incorporated the fundamentals of the theories into their teaching behaviors. It is generally recognized that the teachers teaching science would need regular inservice courses in order to

make the new teaching techniques more effective and to implement the new methods, more fully. In addition, the new teaching skills need to be reinforced during the inspectorates visits so that teachers will not regress to the old ways of teaching.

The inservice teacher education often yields too little in terms of improvement in the actual teaching. The effective implementation of any instructional program largely depends on the skills, knowledge, ability, dedication and resourcefulness of teachers.

Teacher inservice training courses are ill-designed, short inservice programs are non-existent, and if there, are too short.

RECOMMENDATIONS

Examination and Curriculum

- There should be an overall decrease in the emphasis of national examinations in the academic performance as measured through low cognitive process (rote memory).
- The national evaluation of learners should be broadened to include the higher cognitive skills and other categories, heretofore not on the national exams.
- The base of the national evaluations of learners should be broadened to include terminal teacher-made tests given each term, and any innovative ideas and practices by students.

Equipment

More equipment should be provided to the schools through the following:

- The Ministry of Education should allocate more funds for purchase of equipment and insure that funds are spent on equipment and not anything else.
- The Ministry of Education should facilitate communication with headmasters/department heads regarding equipment shortages.

- The institute of curriculum development should organize seminars for teachers on making simple laboratory equipment on their own in schools.

Textbooks and Supplementary Readings

The need for books which depict the Tanzania environment (e.g., biological sciences) is very essential.

Therefore:

- The staff of the institute of curriculum development in collaboration with the subject teachers in various schools should prepare pamphlets or books for use in schools.
- University instructors should be encouraged to publish subject books in different science disciplines.

Retention of Trained Teachers

In order to reduce the attrition of trained teachers, the Ministry of Education needs to make a real effort to retain trained teachers:

- They need to provide pay incentive by increasing teachers' pay to a similar private sector position.
- They need to provide more job security, such as protection from interdiction for minor offenses.
- They need to provide better housing.

Inspection

The inspectorate section of the Ministry of Education should hire more inspectors trained to go out to inspect the science teachers in all secondary schools on a regular basis:

- The training of these inspectors should enable them to provide constructive feedback to the teachers teaching such courses as inquiry or integrated types.
- The chief inspector of schools should be given the responsibility to evaluate the performance of inspectors and should meet with the inspectors regarding the progress of the teachers on a systematic basis.

Teacher Training

Greater effort should be made to train teachers in the heuristic method (inquiry):

- Preservice teachers should be trained in the newer methods of teaching and learning so that they have alternatives to the didactic and understand the value of inquiry and ecological approaches.
- Preservice teachers should also be trained in the process of curriculum development and assessment so they can understand the processes and new curriculum are given to them to supplement them wisely.

- Inservice training needs to be provided to all science teachers so they also may learn the inquiry method and the curriculum development process.

TEACHER EDUCATION FOR INQUIRY

In order to provide teachers with the knowledge and skills necessary to teach science as inquiry and to select the instructional strategies for learning by inquiry, one must provide a central role for inquiry in teacher education. One lecture about the nature of inquiry will not even scratch the surface. A series of diversified experiences, some as part of learning science in the university or college and others as part of the teacher education program, may create the necessary foundations on which teachers may build their own versions of teaching science as inquiry. This claim is strongly supported by research evidence.

Sweitzer (1982) carried out a meta-analysis of research on preservice and inservice teacher education practices designed to produce outcomes associated with inquiry strategy. For this meta-analysis, "a teacher equipped to conduct inquiry would possess questioning skills that are divergent, have a knowledge of science process and have the capability to conduct a student-centered inductive approach." Specific outcome criteria included the following: knowledge of science processes, inquiry instructional strategy, indirect verbal behavior, accepting interpersonal behaviors, increased

wait-time questioning behavior, higher cognitive level questioning behavior, and discovery instructional strategy. The results of this analysis show that inquiry oriented teacher education could significantly improve not only the inquiry behavior of the teachers, but also the knowledge of science processes of their students.

Following are some specific suggestions for preservice education.

Courses in the Specialized Field of Study

Two basic arguments underlie the suggestions here.

(1) While teaching, most teachers draw heavily on their experiences as students. If we can provide learning experiences which emphasize a variety of approaches to the teaching of a particular subject matter area, the students will have acquired the kind of backgrounds which will enable and encourage them to incorporate these approaches later on in their teaching.

(2) The time allocated to specific teacher education courses is limited. If we can find a way to teach the different subject matter courses in the student's own discipline using a variety of inquiry strategies we can achieve simultaneously two sets of goals--students will learn the required subject matter, and at the same time acquire a deeper and broader view of science as inquiry.

The following are some possible approaches to the teaching of science courses at the college level.

a. Courses which incorporate inquiry oriented laboratory investigations. Inquiry oriented laboratory investigations require students to utilize inquiry skills such as formulating problems, formulating hypotheses, designing experiments and collecting and interpreting data. There is no substitute for such experience if indepth knowledge of science is the goal.

b. Courses involving field work. Outdoor field work is an important component in science, especially in biology. The opportunity for students to study natural phenomena outdoors and to apply scientific principles and theories to objects and events in their natural environment adds a significant dimension to indepth knowledge. Students who experience outdoor studies are more likely to use the outdoors as they become teachers.

Teacher Education Strategies

Many prospective teachers do not have the opportunities when they are students in science courses. Much of what they learn about science as inquiry and teaching by inquiry will be conveyed in their methods courses and in practice teaching. Following are a number of strategies that may be used in the methods courses to help give prospective teachers indepth understanding of

science and at the same time, present them with a repertoire of teaching strategies which they may use in their classrooms to get their students to comprehend science as inquiry.

a. Content analysis. Content analysis is a useful way to identify particular characteristics of curriculum materials. The use of content analysis appears to be especially important since "in reality most teachers need new ideas to help them emphasize the inquiry aspects of science and also to use the textbook as a science of inquiry material."

b. Reflective teaching and reflective learning. "Teacher education courses usually include some components, in addition to the actual practice teaching, which aim at teaching how to teach." One familiar strategy is microteaching which frequently follows the guidelines developed by Allen and Fortune (1967) . This approach to microteaching emphasized training in specific skills and may be regarded as an antithesis to the teaching of science as inquiry and by inquiry.

c. Analysis and construction of tests. Exercises involving student teachers in analyzing all kinds of tests including inquiry oriented papers and pencil tests (Process of Science Test, 1962) or inquiry oriented laboratory tests (Tamir, 1974) can contribute significantly to indepth understanding of both concepts and inquiry process. A

special instrument for analyzing inquiry oriented tests, especially practical laboratory tests is now available.

d. Classroom observation as a tool for promoting inquiry. In many teacher education courses, classroom observations using Flander's System or a similar system are employed. Flander's System and many similar systems do not relate to a specific subject matter, but rather aim at general behaviors which are commonly occurring in classrooms. It is possible to design observation schemes which focus on classroom transactions as they relate to inquiry processes and to a scientific discourse. Involving student teachers in actual observations using such observation schemes should add an important dimension to their inquiry training. Such observation exercises may be profitably integrated with field experiences.

e. Field experiences during practice teaching. It should be possible to utilize the field experiences to back up and complement theoretical courses. This is not an easy matter because teacher educators rarely have control of the field experiences of student teachers. The following suggestions may be considered:

- (1) Selecting supervisory teachers who exemplify in their teaching at least some of the features of teaching science as inquiry and who have had experience in matching the level of inquiry to their students' needs. This will require preliminary study of

potential supervisory teachers in order to identify the right candidates.

- (ii) Once these candidates have been identified they may be invited to participate in a special workshop aimed at acquainting these teachers with the rationale and components of teaching science as inquiry. If possible, these teachers can be involved in the planning and development of teacher training activities and assignments in which student teachers make explicit use of their field experiences to enhance the objectives of the program. As a side effect, such a workshop may be considered as an important inservice training for the practicing teachers who take part in it.
- (iii) Special exercises and assignments may be designed which relate to the goals of the program.
- (iv) Rather than treating the field experiences as isolated from other teacher education experiences, it may be beneficial to hold, during the period of practice teaching weekly or bi-weekly seminars in which the instructors discuss problems and issues brought by the student teachers. Such seminars provide excellent opportunity to draw the attention of the participants to ways and means by which learning by inquiry may be enhanced in particular cases under specific circumstances.

CONCLUSION

In Tanzania there is a widespread recognition of the importance of science and technology in fostering human well-being, and meeting the economic and political demands of living in the twentieth century. For Tanzania to meet these goals will require a knowledgeable and concerned public, as well as specialists in the generation of scientific knowledge and technological innovations. The commitments of secondary education in the sciences and technology must be to the general public. There is a vast amount of scientific information that should be a part of human experience, not only for its usefulness in advancing human welfare and the nation. To achieve a science education with these ends will require the cooperative endeavors of scientists (including teachers), government officials, school administrators, curriculum developers, and national examination council, and others with positive vision of Tanzania's future. These people will need groundwork for a science curriculum in the sciences and technology that has both scientific and cultural validity.

Moreover, the role of inquiry in science education has been one of the most controversial issues in the last 20 years. While by and large, inquiry has not gained prominence in most classrooms, one can, nevertheless, find

examples of successful teaching of science as inquiry. Many teachers in Tanzania have demonstrated that both teaching science as inquiry and learning by inquiry can be accomplished. Meta-analysis of empirical studies provides strong evidence in favor of inquiry in science classrooms. This project paper intended to offer a rationale as well as practical suggestions which may help teacher educators in preparing student teachers to carry out the recommendations of namely that every expected student outcome with respect to inquiry in science education should have psychological consistency, be compatible with personal goals and have ecological consistency. A reform in teacher education programs of the kind suggested here may be the key for more successful implementation of inquiry oriented science teaching in our schools.

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