The Current Situation In The Training Of Mathematics And Science Teachers In Africa And Some Suggestions For A Sustainable Future[1]

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Abstract

Africa finds it difficult to respond to the gap created by the digital divide because she lacks one of the most basic resource - teachers. Mathematics and science teachers in Africa need to be conversant with the understanding of Science and Technology for national economic development, life, independence and autonomy of each individual. They may best acquire mastery of these by attending institutions that develop in them theoretical perspectives sensitive to the cultural, social, gender etc backgrounds of the pupils, provide for the knowledge of the 15 – 16 years olds with regards to their experiences, interests, priorities, images and perceptions of relevance to their learning of science and technology.

There is now very limited training and recruitment of mathematics and science teachers due to the economic crisis, although the number of secondary schools has been on the increase in Cameroon. This has resulted in more pupils without teachers. Mismanagement of the few available, conscientious mathematics and science teachers has also constituted another reason for the shortage.

In many countries there is reduced interest in science and technology studies, noticeable decrease in the number of students opting for sciences and a growing gender gap in choice of science and technology subjects. Consequently many interest groups such as industry, university and research institutions and educational authorities have voiced their concern about this. The concern also includes the quality of the numbers, and this consequently sets competition among the stakeholders for those with mathematics and science background.

As concerns policy and regulatory framework, some African countries have made efforts to establish regional mathematics and science associations, regional modality for monitoring and evaluating the impact of in-service training programmes as a way of strengthening networking and collaboration, and to exchange experiences related to teachers' mastery of content, pedagogic skills, and attitudes needed for quality teaching and learning in science and mathematics. Development needs for training of mathematics and science teachers in Africa today include infrastructure, equipment, personnel (technicians), policy to regulate these, and above all, the will of governments. Partnership and collaboration with developed countries for various levels of training remain the best ways out.

It has been observed that the strategies for open and distance learning to improve the quality and reach of teacher training programmes are not very good in some African countries and needs to be encouraged.Besides the effective use of information and communication technologies (ICTS) in the classroom is still a dream in many African countries including Cameroon. Uganda seems to be moving fast ahead in this area.As a way forward, African countries need to establish a model for the training of teachers to use

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[1] **Text of an invited Paper for presentation at the International Conference on Education for a Sustainable Future – ESF, 18-20 January 2005, organised by the Centre for Environment Education, Ahmedabad, INDIA.**

1CTS in mathematics and science education, provide easy access to 1CT resources for students, produce quality software and internet resources in widely used languages of Africa, and the Ministries of National Education should purchase copyrights of the necessary software in these subjects for use in schools.

African countries should adopt an increasingly human- based focus in science teaching. Computers should be assigned their proper place in the current history of science and technology as a powerful, problem solving resource. A national or regional centre for teachers training in science education and the use and validation of new educational technologies should be set up with technical assistance from funding agencies. There is need for an African science/ society contract in which all citizens should possess a certain level of scientific literacy that allows them to understand, act reasonably and responsibly in daily life and participate actively in the search for solutions to problems.

1.0 Introduction

As the world enters the technology era and leaders worldwide grapple with the challenge of helping to close the digital divide, Africa finds its capacity to respond to these challenges undermined by its lack of one of the most basic resources – teachers. Whether and how Africa participates in this knowledge era and meets global Education For All targets will depend on its success in training new teachers, upgrading existing teachers and extending the reach of all qualified teachers. Before it gets too late, it should be understood clearly that the urgent need for all Africans is to develop a high level of mathematics and science literacy than what presently exists. Mathematics and the sciences will help create products and services, standard of living and economic and military security that will sustain all of us everywhere. From these subjects will emanate the technological creativity we need to compete effectively in the global marketplace. Scientists and mathematicians, like all other citizens, have an obligation to comprehend the significance of their knowledge and relate it to issues that challenge society, so that together with others they put into practice the processes that lead to solutions.

To attain this high level of literacy requires a concerted, conscious effort on part of the entire education community (system) and sustained opportunities to develop it (Sutman, 2001).

2.0 Content

2.1 Mathematics and science teachers in Africa need to be familiar and conversant with a broad understanding of Science and Technology:

(a) For national economic development, and

(b) For the life, independence and autonomy of each individual.

2.2 How do they best acquire a mastery of this content?

The lack of relevance of the science and technology curriculum is probably one of the biggest barriers to good learning and interest in the subject. Teachers training should aspire to provide theoretical insights into factors that relate to the relevance of the contents as well as contexts of the Science and Technology curricula.

The teacher trainers and curriculum developers should therefore aim at:

(a) Developing in the teacher and curriculum theoretical perspectives sensitive to the diversity of backgrounds (cultural, social, gender, etc.,) of the pupils.

(b) The teachers training should provide for knowledge of the (15-16 year old) pupils with regard to their experiences, interests, priorities, images and perceptions that are relevant to their learning of science and technology and their attitudes towards the subjects.
(c) Trainee teachers of mathematics and science should be exposed to a wide range of countries and cultural contexts with regard to the above-mentioned aspects.
(d) The policy development and recommendations for improvement of curricula, textbooks, and classroom activities should be based on (a) to (c) above.
(e) Teachers of mathematics and science while in training and thereafter should be encouraged to participate in public debates on issues related to the relevance and importance of science and technology.
(f) Such teachers should remain updated by their participation in scientific and educational fora.
(g) Retraining is another important element of the teachers updates (Sjoberg, 2001).

2.3 To What Extent should Mathematics and Science be relevant to work force needs?

There is evidence that pupils perceive school science as lacking relevance and is often considered dull, authoritarian, abstract, and theoretical. The curriculum is often over crowded with unfamiliar concepts and laws leaving little room for enjoyment, curiosity and a search for meaning. Also, it often lacks a cultural, social and historical dimension and seldom addresses contemporary issues. Science used to be seen as a search for knowledge driven by individual curiosity. Historically, scientists have rightly been described as radicals and revolutionaries who often challenged religious and political authority. Contemporary science is different in a number of fundamental ways as can be seen in the fusion between science and technology into what is now called techno-science. Scientists and engineers today often work for national, industrial or military interests. Therefore at all levels of educational training of mathematics and science teachers, the relevance of Mathematics and Science to the work force needs should be emphasized.

3.0 Recruitment

3.1 How does the Education establishment recruit and retain qualified Mathematics and Science Teachers?

Economic crisis has become the dictate of all efforts. Formerly, in Cameroon the education establishment gave scholarships to a large number of Advanced level GCE holders who qualified for and were interested in training in Mathematics and the Sciences. They were trained for two to three years and successful candidates were posted to first cycle secondary schools only. Those who took a further two years or had trained outside the country to a masters level degree were recruited and posted to higher schools. Here, the government had the monopoly of the science and mathematics individuals, more so because it paid the highest salaries to personnel of national education. The retention of qualified Mathematics and Science teachers has been by virtue of a higher salary, and certain incentives – technical and evaluation allowances to teachers in general.

Today, not many are recruited or trained, while the number of schools and consequently the number of students has increased tremendously. As many teachers retire from service, some are taken away by the HIV/AIDS pandemic, and many more subject to mismanagement, the schools remain bereft of science and mathematics teachers. The

problem arises when less qualified science and mathematics teachers or the social science teachers supervise the more qualified science and mathematics teachers. This alone has discouraged many individuals with mathematics and science background from entering into the teaching field, and those already in from being duty conscious, except those who were genuinely committed. This has also contributed seriously to the shortages of mathematics and science teachers in schools.

3.2 Is there competition for these individuals with the private sector, government, or donor organizations?

To determine this factor, it is important to examine the following challenges:

1). In many countries, interest for Science and Technology studies is falling – or at least not developing as rapidly as planned or expected.

2) In many countries there is a noticeable decrease in the number of students choosing sciences especially at the tertiary level.

3) In many countries a growing gender gap has been observed in the choice of science and technology subjects both at the school and tertiary levels.

4) Concern about unsatisfactory enrolment is voiced by many interest groups –

(a) Industrialists worried about the recruitment of a qualified workforce.

(b) Universities and Research Institutions about that of new researchers.

(c)Educational authorities about the already visible lack of qualified science and mathematics teachers. In some countries the difficulty of recruiting sufficient numbers of new candidates in the teaching profession has become a matter of national concern. This concern is not just limited to numbers. It is identifiable with the fall in the quality of the newcomers. Learning science generally requires hard work and considerable intellectual effort -- no longer a dominant part of contemporary youth culture.

Consequently, there is serious competition for these individuals with mathematics and science backgrounds. The stakeholders (named above) face the competition and challenges. In some countries, to reduce the competition, the stakeholders sponsor their would-be candidates for training. In Cameroon, the government sponsored the training of mathematics and science teachers who were automatically absorbed upon graduation. Here government paid higher salaries to teachers than other stakeholders. Today, the situation has been changed because of economic crisis and everybody competes for the few mathematics and science teachers who may manage through the training on their own. As there is no employment now of science and mathematics teachers by the government, many qualified individuals try to find better-paid jobs elsewhere. It is high time African governments kept their own science and mathematics oriented nationals, to reduce the brain drain, they already suffer from.

3.3 Who or what is creating the demand for school graduates with higher levels of mathematics and science skills?

The problem of interest (demand) in mathematics and science graduates can be viewed from different perspectives. As different viewpoints suggest different solutions, the following possible stakeholders and their arguments may create a demand for school graduates with higher proficiency in mathematics and science.

(1) Schools need well–qualified and enthusiastic teachers as they constitute the key to all improvement of science and technology in schools and for the further development of knowledge, interests and attitudes of citizens once they have left school.

Mathematics and science teachers need to provide not only a good foundation but also perspectives on science and technology in a historical and social context. The long-term effects of shortage of good science and mathematics teachers can be very damaging, although not immediately noticeable as in industry and research.

(2) Universities and Research Institutions have a similar need for researchers and teachers of mathematics and sciences to maintain research at high international level and to provide good learning possibilities for coming generations of experts, researchers and teachers.

(3) The Industry eeds highly qualified people in mathematics and sciences as modern industry is high-tech and often referred to as a "knowledge industry". To survive in a competitive global economy, it needs highly qualified scientists and engineers. This aspect is important for the economy of the nation.

(4) The Modern Labour Market requires qualified people in mathematics, sciences and technology because these are the pre-requisites in the new and emerging sectors.. There is also a general need for greater flexibility and learning skills. A good grounding in science, mathematics and technology is of great importance since most of the changes in the labour market are likely to be derived from scientific and technological research and development.

5) Citizenship and democratic participation
In contemporary society dominated by science and technology, citizens as consumers have to take decisions on food, health, quality and characteristics of products, and advertisement claims, to name a few. On the other hand as voters, they have to take a stand and be able to judge arguments on a variety of issues -- many of which have scientific/technological dimensions. Under the circumstances, a broad public understanding of science and technology can act as a democratic safeguard against "scientism" and a domination of experts. Although everyone cannot become an expert, one should have the necessary intellectual tools to be able to judge which experts and what kind of arguments to trust.

In fact, the challenge, Sjoberg, 2002 has argued, is how to combine these different perspectives and concerns in a flexible education system that includes life–long learning.

In this context, some of the options that need to be considered are as follows:

(a) Should one favour early specialization, identification and recruitment of the more able?

(b) Should one have a comprehensive system for all (to what extent and up to what age?), or should one introduce streaming and selection?

(c) Should one maximize pupils' individual freedom to choose according to interests and abilities, or should one postpone choices and hold on to a core curriculum of important contents to be covered by all?

(d) How should one support lifelong education and develop adult education and on-the-job training?

Different groups should be able to work together to achieve what is often called "scientific and technological literacy." Other issues are more controversial, for example,. how critical should school science and technology be of authority, industry, military, or at what stage should selection and specialization be started/encouraged in order to identify and recruit talented students for higher science and technology studies? Therefore it is a difficult task

for educational and political authorities to balance contradictory concerns and stimulate public debates on these important issues.

Finally, if one accepts that the problems of recruitment and attitudes to science and technology are embedded in a wide socio-cultural context, the search for solutions will necessarily require a broader approach than that limited to reforming schools, universities, teachers training institutions or their curricula. One will need to look beyond the education system and involve different stakeholders. There is need for context specific reforms with a multi-dimensional approach and long-term implementation.

4.0 Policy And Regulatory Frameworks

4.1 The current policy and practices of teachers training programmes in Africa.

Some African countries have been making an effort to develop policy and practices for teachers training programmes. Some such countries include Kenya, Lesotho, Ghana, Malawi, Mozambique, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. These countries have made efforts to establish a regional mathematics and science association among the countries represented; a regional modality to monitor and evaluate the impact of in-service training programmes as a way of strengthening networking and collaboration; and to exchange experiences related to teachers' content mastery, pedagogical skills, and attitudes needed for quality teaching and learning in science and mathematics. These countries have met at a second regional conference to develop further understanding of ASEI (Activity, Student, Experimentation and Improvisation) and PDSI (Plan, DO, See, Implement) as key methods of and strategies for enhancing classroom activities (Nengo, 2003).

4.2 To ascertain the regulatory framework

The participants at the regional conferences developing these policies were Directors of Education, School Inspectors, Head teachers, Heads of Departments, and Practicing Mathematics and Science teachers. The policy developed also accepted the following viewpoints: 1) to build innovative skills through mathematics and science fairs and congresses at all levels 2) to institutionalize and regularize in-service-training for teachers at all levels 3) to form subject associations at all levels 4) to maximize the use of resources through sharing 5) to get all teachers to use a gender–friendly methodology in teaching 6) to ensure that curriculum developers and producers adopt educational materials with gender-neutral approaches 7) encourage teachers to adopt the ASEI movement and the PDSI approach.

4.3 Participation. Although some efforts have been made, not all African countries participate e.g. Cameroon, Nigeria, to name just a few. This difficulty could arise from inappropriateness of the activities to other countries, and other factors (Kinyua, 2001). Among the difficulties of training mathematics and science teachers today the question of personnel (trainer) also arises. Some of the outdated elements of the curricula go along with their authors. While there is need to update and renew the mathematics and science curricula, similar difficulties exist with replacement of the old personnel, some of whom have retired or are about to retire. The update is for both staff (trainers),and the curricula.

The development needs for the training of mathematics and science teachers in Africa today are those associated with infrastructure and equipment. Good training for mathematics and science teachers need to be carried out in well-structured and equipped environments. I am thinking here of well equipped science as well as electronic laboratories. Trained resource persons would be required to handle these laboratories which would facilitate the training of teachers.

There is need to set up a policy that will streamline these difficulties and developmental needs. Partnership and collaboration with other developed countries for various levels of training remain the best ways out, while seeking ways and means of conducting on-the spot or in-service training.

5.0 Mechanism Existing For Feedback Between Teachers On The Ground And The Educational Ministry

In Cameroon, there is really no direct feedback mechanism between mathematics and science teachers in the field and the Ministry of National Education. However, all mathematics and science teachers are expected to be evaluated through inspection by the Pedagogic Inspectors. It is only in this way that there may be some kind of a feedback from the individual teacher to the Ministry. The other problem is that the inspection may itself never be done by the authorities concerned, thereby blocking or limiting the possible mechanism for some feedback.

Subject reports and many times seminars at which teachers are required to present papers based on classroom experiences could also be a mechanism for direct feedback if the ministry frequently organizes them. Support by the Ministry of the National Organizations of Mathematics and Science Teachers Associations and encouraging these to network with similar organizations in other countries to share experiences would go a long way to improve the feedback mechanism.

6.0 Strategies For Training:

6.1 The potential for open learning programmes to improve the quality and reach of teacher training programmes.

The strategies for training of teachers of mathematics and science have not always been very encouraging in some African countries. In Cameroon, after the Advanced Level Certificate in the appropriate subjects, it was earlier possible to enter the Advanced Teacher Training College (ENS, Ecole Normale Superieure) without any age limit. Today it is not the same, an age limit of 27 years has been imposed for those applying to enter. Besides, if the Advanced Level Certificate was earned more than 4 years before the date of application for entry, the candidate would not be accepted.

This age limit and by implication the expiry of one's certificate, have not been very progressive measures in terms of open learning. They are rather inhibitory and discouraging and affect the reach and quality of teacher training programmes. In some African countries such as Nigeria, these barriers to further training opportunities do not exist. This open learning system should be encouraged in our African countries since we are leapfrogging with science and technology today.

6.2 Potential for distance learning**.**

Distance learning is not a new concept to anglophile Africa. It has been well known in the English-speaking nations of Africa since their association with the British. The emergence of the multi-cultural status of many African nations has had a large influence on the acceptability of the concept of distance education in different African states. In Cameroon, it was well known in the English speaking part, but today, it would sound like a new concept in the entire territory.

As a strategy for training, distance learning has not been introduced or exploited in many African countries yet, although it would be an interesting idea if the requirements can be met. African countries are always complaining of being poor. I am thinking here of the facilities required both by the trainer and the trained. This is an important area to be exploited especially with the advent of information and communication technologies. It will also enable those individuals to further their development for functioning in society if and when an age limit excludes them from jobs or entry into higher institutions. However, it must be accepted that even when introduced, people in African villages who need much education may not still be able to afford the means,unless very thoughtful consideration is given to them.

7.0 Teachers And ICT

The effective use of Information and Communication Technology (ICTs) in the classroom is still a dream in African countries like Cameroon. It requires equipment and e trained teachers for this purpose, of which at the moment there are none. It also requires the commitment and interest of the professional teachers.

Mechanisms for equipping teachers with ICT skills for teaching are not yet available in many African countries like Cameroon. However, I have visited Uganda and seen how this has been well developed to a very reasonable extent worth emulating. They have some very interesting programs at the Institute of Computer Science, Department of Mathematics, Makerere University, Kampala.

In Cameroon today Government is introducing computers into some sample secondary schools. Many private and other public schools, having realized the importance of information technology, are doing all in their powers to buy computers for their schools. Some are using the Parent Teacher Associations to achieve their objectives where the associations have seen the importance. However, the major problem remains that the teacher training institutions have not yet designed a program that will train the mathematics and science teachers to teach using the technologies. This is where the will of the African (Cameroon) Governments is needed to develop the much-required workforce.

There is a need to train interested and committed mathematics and science teachers in the effective use of these Information and Communication Technologies (ICTs) so that these can be applied in the classroom. In Cameroon, our mathematics and science teachers have not yet been initiated into computer literacy so that they can incorporate ICTs into their teaching methods.

8.0 The Way Forward

It is important in view of the above, to establish a model for the training of teachers to use ICTs in mathematics and science education in Africa that will:

- Ensure that all schools benefit from the effects of the training.
- Provide easy access to ICT resources for students.
- Produce quality software and Internet resources in English, French and other important languages used in Africa.
- Identify highly competent personnel to form the first cadre of trainers. These should be provided continuous training in order to keep them updated.
- Provide training to inspectors as well as access to ICTs.
- Encourage a multicultural approach to science education.
- Ensure that science teachers pass the practical examinations and laboratory management is a part of teachers training
- Allocate fewer periods to science teachers or pay science teachers higher salaries in the form of a laboratory allowance.
- Create a database of science educators in service, in training, and those that graduate each year.
- Supply of science equipment must be accompanied by training on how to use that equipment (Muwanga-Zake, 2004).
- The Ministry of National Education should purchase copyrights of the necessary software in science and mathematics for use in schools, and provide technical support during seminars and workshops.

Also, collaborative efforts could be made with other developed countries aimed at supporting African (Cameroonian) high school teachers' efforts in raising the quality of teaching and learning in mathematics and science. This may require the participation of most secondary schools in a given country in the project, which may have the following tasks:

1) Basic Education -- Four teams (Biology, Chemistry, Mathematics and Physics) support initiatives in schools concerning qualifications, knowledge and contents that students need when leaving secondary school. They aim at working out interdisciplinarily inter-connected concepts for basic education at the Upper Secondary level in the four subjects.

2) School Development – This team supports schools that have a focal point in mathematics and science teaching. It tries to establish a network of such schools, and aims at working out a concept that reflects the initiation, support and evaluation of school development processes that focus on the enhancement of mathematics and science teaching.

3) Teaching and Learning processes – The team supports innovations in schools focusing on situation – appropriate teaching and learning processes and also aims at working out a concept for generating, analyzing and evaluating such processes, supplemented by materials like a CD with video-clips of real teaching that is intended to be used in teacher education.

4) Practice–Orientated research – The team will support teams of school teachers or University teacher educators (or mixture of these) who carry out investigations in their own teaching or action research or classical research projects and aims at working out a

concept for the promotion of subject-didactic research, and culture (Ghada, 2002, Project IMST^2).

- An increasingly human-based focus in science teaching that underlines its contribution to general culture and pays special attention to ethical issues related to scientific-technological development.
- Familiarising students with methods and ways of thinking and behaving that characterise modern science research.
- Developing in children a critical and reflective attitude instilled with responsibility and solidarity together with a sense of transformation in the face of human and environmental problems.
- Fostering ways of interchange among the mathematics and science teachers to contribute to the improvement of their work and raise the quality of education.
- Many science curricula and specially classroom teaching practices still reflect decade – old attitudes. It is necessary to pay great attention to pre and in-service training of mathematics and science teachers where stress is laid right from the beginning on the link with the existing situation in schools.
- Science and Technology Education should be made accessible to children of all horizons to meet up with the science teachers training (Blueford and Rosenbloom, 2003).
- Special emphasis should be laid on the analysis of relevant problems from the social as well as personal viewpoints. The role played by practical activities in science teaching should be reviewed to integrate them coherently in the process of problem solving and to foster reflective thinking in students.
- Computers should be assigned their proper place in the current history of science and technology as powerful, problem-solving resources.
- Production of knowledge in science education, development of action-based programmes and creation of work groups and links at the school, national, regional, and international levels should be stimulated. These programmes should receive strong support from governments and Education Ministries, as well as international organizations, and target three key elements of educational change: Pre-and in-service science teacher training, science research and school practice.
- A national or regional centre for teachers training in science and mathematics education and the use and validation of new educational technologies should be set up with technical assistance from funding agencies for developing educational software, and the work of the chair (Director) on science education should be broadened (Macedo, 2001).
- There is need for a new science/society contract which demands that all citizens should possess a level of scientific literacy that allows them to understand and act reasonably and responsibly in daily life and participate actively in the search for solutions to problems.

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