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THE PROBLEMS OF MAINTENANCE OF SCIENTIFIC AND TECHNICAL EQUIPMENT AND THE EFFECT OF IT ON RESEARCH AND EDUCATION IN AFRICA

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Abstract
Developing countries are regarded as recipients of technology and advanced scientific equipment, however most of equipment is unavailable due to breakdowns and lack of maintenance. Maintenance of scientific and technical equipment appears to enjoy very low priority in the main activities of Universities, Research and Technological Institutions in Africa. These institutions are expected to train manpower in the fields of science and engineering and to conduct research at a level comparable to other similar institutions worldwide, but this cannot be achieved if essential instruments/equipment and facilities needed for this purpose are unavailable or are not maintained. This paper highlights the problem equipment maintenance, the possible causes and the initiatives taken by the International Foundation for Science of Sweden and the Network of Users of Scientific equipment in Eastern and Southern Africa (NUSESA) in addressing the problem. The paper also suggests priority areas, which need to be addressed, and makes recommendations for the way forward. In looking at the priority areas, the paper attempts to tackle the problem of technology transfer and ways in which the equipment suppliers and the users can work together to address the problems.

Key words: equipment • maintenance • training

1. INTRODUCTION

Africa is a rich continent: rich in biodiversity, natural resources like minerals and precious stones. It is a continent rich in traditional knowledge and culture. But, Africa is a poor continent, with about 13% of the world's population, and only enjoys only 1% of the world's wealth. [1]. Africa is a recipient of technology from the developed countries.

The past, two to three decades has seen advancement in technology with a lot of new equipment being marketed. In addition, developing countries have been recipients of new equipment and a lot has come through as donations or grants given by the developing countries under bi-lateral agreements. Many research projects of considerable benefit to the developing countries have been supported and frequently, those conducting research have also benefited e.g. by obtaining higher degrees. Through these projects, we have seen lot of equipment come into the institutions. However despite this influx of the equipment progress in research and education have been hampered due to equipment breakdowns. Such equipment breakdowns are primarily due to lack of maintenance.

Maintenance of equipment seems to have very low priority in the design of the projects and in connection with the acquisition of new equipment. Emphasis is placed primarily on the results of the research but the importance of proper functioning of the equipment is often neglected. Most of the institutions seem to have no clear policy on equipment. Equipment is bought in a haphazard manner and no procurement and maintenance policies are in place. There is also no policy on donated equipment, whatever is offered is gladly accepted even when it might not be used or might not be compatible with the environment in which it is going to be used.

It is unfortunate that Africa is perceived to be a very small market by the equipment manufacturers, therefore very little attention is paid to the equipment problems coming from African countries. However, when the service is available, it tends to be very expensive and most institutions do not have sufficient funds for servicing of the equipment. Service from local agents and local suppliers is usually poor as few persons are trained to maintain the equipment.

There appears to be no systematic planning of equipment replacement. Equipment is kept working as long as possible without support from the manufacturer or supplier. This is often frustrating for the researchers who often have been trained in developed country and there have become used to modern functioning equipment.

The teaching of practicals in universities and technological institutions has been badly affected by non-availability of functioning or inadequate equipment. Only a few working instruments are available for demonstrations and projects for the large classes now common in African Universities. The result is a "half baked" student with little exposure for the use of scientific instruments.

Equipment surveys have been done, problem areas have been identified, and over the past ten years, attempts have been made by donors and others to address the maintenance of equipment. Equipment maintenance centres have been established across the countries to support maintenance and repair equipment. Some donor organisations have included in their projects an element of equipment maintenance for

the duration of the project to make sure that the research results are collected and the project completed. In some cases, experts from the donor country have been brought in to look after the equipment for the duration of the project. However, after the project is completed, the equipment breakdown might mean the end of the use of that piece of equipment as maintenance problems arise.

A lot of training programmes and activities has taken place in the last 15 years. However despite these efforts the problems of equipment maintenance persist.

Perhaps the most significant impact in addressing the maintenance problem was the establishment of the Network of Users of Scientific Equipment in Eastern and Southern Africa (NUSESA). Established 13 years ago NUSESA has membership covering 16 countries in Eastern and Southern Africa and provides a forum for addressing the equipment problems. Its presence in almost all the universities and research institutions in the sub-region provides a unique opportunity for exchange of ideas and sharing of resources in the use and maintenance of scientific equipment.

2. THE MAJOR PROBLEMS IN EQUIPMENT MAINTENANCE

The main problems can be divided into two; administrative and technical problems. The administrative problems are to do with policies, guideline, or regulations, on procurement, training,, usage, maintenance and condition of service. The technical problems would be in the same areas but of technical nature and include others things like specifications, installations, use, maintenance and repair.

Below is a summary of some of the major problems associated with equipment maintenance. These are based on experience gained from interactions with users of equipment and others over the past ten years, which have been identified as being the main areas contributing significantly to the equipment maintenance problems.

2.1 Administrative problems

Administrators play a very significant role in the life of equipment. It seems low priority is given to the allocation of budgets for maintenance, spares, manpower training and replacement. Most administrations of African Universities do not have equipment policies. Purchase of equipment is left to the departments and sometimes to an under informed tender board. Some equipment and instruments are under-utilised and yet new equipment of the same is bought. There is no standardisation of equipment to minimise the problems of maintenance.

When equipment is bought, no training component is included. Sometimes the researcher goes for the training, which is actually meant for the technical person. Working conditions for technical staff are often neglected and as a result competent maintenance technicians are lacking and often are taken up by the higher salaries and better working conditions in the private sector.

A survey conducted in the late 80's by Jacques F Gaillard and Said Ouattar found that operational rules are sometimes rigid and make it difficult to have a budget dedicated to maintenance and repair of equipment. In some institutions when an instrument breakdown the rules demand that three different quotations be submitted. This procedure is unworkable because the repairers do not wish to invest in giving free diagnosis as a result the estimates are inflated. [2]

Lack of national funding availability and government and institutional commitment in supporting equipment maintenance and equipment replace is a major concern. Severe cuts in government spending have pushed institutions of higher learning and research centres into steep decline.

I believe an equipment policy with guidelines covering all aspects of the equipment life including selection, procurement, purchasing, installation, training, use, replacement, repair and maintenance would go a long way in addressing some of the above problems. The importance of equipment and equipment maintenance has to be re-emphasised to institutions and to Governments if we are to do any meaningful research and develop in Science and Technology in Africa.

2.2 Donated equipment problems

A large number of scientific equipment and instruments is received by institutions through donor-funded projects. Equipment is given to a research group or research centre or to a researcher doing a specific research project. The procurement procedures are not standardised and in a number of cases, equipment is brought without consulting the recipient. There are institutions where donated equipment is lying idle uninstalled because there is no room to put it or there are no funds for the installation. Institutions sometimes do not have adequate budgets to maintain the very expensive instrument even to buy the basic consumables like gas and chemicals, which are required to run the instrument. The training component is usually not included or only the researcher has the privilege of being trained. The technician who will maintain the equipment is excluded.

However, despite the problems with donated equipment, donors have assisted a large number of scientists in Africa to obtain higher degrees through research projects. It is unfortunate that there is now a decline in funding by donors.

2.3 Technical problems

Even when budgets for the purchase of scientific equipment are available, researchers often lack basic information concerning the equipment to be purchased. Catalogues are often limited and access to the Internet is hampered by slow communication. There is little or no consultation with technical personnel. Basic mistakes like purchasing equipment, which operates at 60 cycles for a country where 50 cycles is standard. This could be avoided if the technical personnel were consulted. The choice of equipment is often determined much more by consideration of prestige rather than by specific scientific and educational needs. No consideration is given to standardisation. During procurement inadequate consideration is given to spare part

problems and as a result equipment may lie idle for months when broken down whilst the spare part is being secured.

The problem of inadequate funds has been mentioned but often is felt more when equipment needs to be repaired or maintained. There is need for harmonised procedures of preventative maintenance and protocols.

Installation of acquired equipment may take long due to inadequate preparation.

Equipment is often under-utilised because the users are not aware of the full potential of the equipment.

2.4 Equipment Manufacturers and Suppliers problems

For manufacturers of scientific equipment, markets in developing countries are of marginal interest. After sales service is rarely provided and if available is through suppliers and agents. Some suppliers and agents are inadequately trained for the equipment they sell and offer very poor costly service. Manufacturers refuse to give circuit diagram that could otherwise assist in diagnosing equipment problem. Maintenance manuals are often inadequate and are not "user friendly".

Ancillary equipment or accessories like computers, pumps, chillers etc when purchased through the supplier are very costly because of high mark-ups for handling.

Africa is perceived as very small market by the equipment manufacturers and therefore no effort is made to design equipment for the conditions in Africa. For example, humidity and temperatures are very high in some places in Africa and therefore instruments from Europe would not function adequately without dehumidifiers and air conditioners. On the part of the African Scientist no noticeable effort is being done to design and market scientific instruments for local conditions.

3. THE EFFECTS OF MAINTENANCE PROBLEMS

The major effect of maintenance problems is the unavailability of functional scientific equipment. Lack of functional equipment affects research and education and our effort in developing in science and technology are greatly reduced. This is clearly illustrated by Table 1.

Table 1 shows the condition of equipment at some departments at Makerere University in Uganda. From the percentages shown, it is evident that the Faculty of Science have working equipment with percentages of good working conditions from 76 to 100%. Unfortunately, this relates to basic equipment required for undergraduate work only. As a result, there are very few publications coming out of Faculty of Science, mainly because of lack of scientific equipment for research. Much of the equipment that was purchased for research was never installed.

In the Faculty of Veterinary Medicine, the percentage of equipment that is categorised as obsolete is relatively high; despite this, the Faculty enjoyed 10 years of support provided by GTZ (Deutsche Gesellschaft fur Technische Zusammenarbeit)

The Ambulatory Clinic, which runs on a more or less commercial basis, has no equipment breakdown and if it breaks down, it is replaced or repaired immediately.

Students intake in institutions of higher learning Universities have increased tremendously in the last decade. A number of these have to use instruments for their practicals or projects and therefore adequate exposure to the instruments is very important. However, the situation now means we are lacking in providing this. The effect could be felt more when the student graduates and becomes a lecture, his practical knowledge would be poor.

TABLE I. Summary of Equipment in various Departments at Makerere University

Faculty /Dept.	CONDITION				
	Work-ing good (%)	Work-ing fairly (%)	Down but repair-able (%)	Obsole-te / Not work-ing (%)	Not Instal-led (%)
Science					
Chemistry	82	5	7	5	1
Botany	100	0	0	0	0
Biochem.	76	1	17	0	6
Vet Medicine					
Ambula-tory Clinic	100	0	0	0	0
Anatomy	10	69	9	11	1
Surgery	60	2	7	31	0
Public Health	51	3	30	16	0
Medicine	84	0	8	8	0
Physiolog y	72	2	16	10	0
Parasito-logy	84	0	2	14	0
Microbio-logy	67	12	13	8	0
Pathology	12	78	6	4	0
Reproduct -ion	60	34	6	0	0
Agricul-ture					
Food Science	75	0	17	1	7
Agric. Engineer-ing	49	0	21	30	0
Agricultur e Extension	43	0	52	4	1

Source: The Fate of Donated and Purchased Equipment in Uganda – A Critical View Prof B T Kiremire and Dr N H Kirsh (Maintenance of Equipment for the Advancement of Science – Proceedings of 1st Regional NUSESA Equipment Maintenance Conference in Africa December 2001 Uganda)

4. ADDRESSING THE EQUIPMENT MAINTENANCE PROBLEMS

Initiatives have been taken to address the equipment maintenance problems. These have been in the form of training workshops, conferences, establishment of maintenance centres, spare parts support, technical support and user training. I mention below attempts made or being made in addressing the problems:

- ANSTI (African Network of Scientific and Technological Institution) and GTZ (Deutsche Gesellschaft fur Technische Zusammenarbeit) conducted some training courses for several years in the region on equipment maintenance in the late 1980's and early 1990. Workshops were held on Management and Organisation of Equipment Maintenance at African Universities in West, East and Southern Africa. [3]
- In November 1991, a planning workshop on Advanced Training, Servicing and Maintenance of Scientific Instruments and Equipment in Africa was held at ICIPE (International Centre of Insect Physiology and Ecology) in Nairobi Kenya. Amongst the workshop aims was the identification of specific action plans towards the effective creation of training strategies. However there was no follow up activities after the workshop and the ideas gathered now lie on the shelf. [4]
- SPALNA (Soil and Plant Analytical Laboratories Network of Africa) with assistance from IITA (International Institute for Tropical Agriculture) and other donors conducts training courses for scientist and technicians in the agriculture analytical laboratories. They have successful training programmes, which include: Good Laboratory Practices, Information Management, Equipment Maintenance and Fabrication, Soil, Plant and Water Analysis and Standardisation of Methodologies and others. [5]
- IAEA (International Atomic Energy Agency) have a project to assist member countries with the maintenance of nuclear instruments.
- The World Health Organisation has also been carrying out service and maintenance activities in health system. They have collaborated with governments to address the problems. In 1987, a Resolution WHO 40.30 on Economic Support for National Health for All Strategies was adopted by the 40th World Health Assembly where it urged Member States, inter alia, 'to establish a programme for better management and maintenance of equipment through appropriate procedures, training of personnel and ensuring the availability of spare parts'.[6]

IFS (International Foundation for Science) with the support from donors started a training programme to address equipment maintenance in 1989. It was during the first training course that NUSESA (Network of Users of Scientific Equipment in Eastern and Southern Africa) was started.

In the following sections, more details are given on what NUSESA has done and is doing in addressing the equipment maintenance problems.

4.1. A Strategy for Addressing Equipment Problems - NUSESA Approach

4.1.1 Background of NUSESA

During the first maintenance training workshop, organised by IFS in Harare Zimbabwe in 1989, the need was emphasised for more information and better co-ordination of activities aiming at improving the use and maintenance of scientific equipment in the region. There was also felt a need to share experiences within the region on issues related to equipment problems and to come up with recommendations to alleviate these problems, tailored to the local/regional situation. In order to meet these needs the Network of Users of Scientific Equipment in Eastern and Southern Africa (NUSESA) was initiated.

NUSESA is a sub regional, non-governmental, non-political body whose basic aim is to provide a forum for information and discussion on proper purchase, use, operation and maintenance of scientific equipment in Eastern and Southern Africa. With such a broad objective a range of activities could be accommodated under the network programme, e.g. training programmes, service and repair services, inventories, advisory functions, etc.

Initially NUSESA depended largely on IFS for support but in 1996, a regional office was established in Harare with IFS support. This organisational change allowed NUSESA to approach donors from a Regional platform, provide skilled expertise from the region to deal with equipment problems rather than depend on expertise from overseas.

4.1.2 Membership of NUSESA

NUSESA has membership in 16 countries in the region namely: Botswana, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. The membership is drawn mainly from technicians, technologists, engineers, researchers and lecturers from universities and research institutions in the region. However there are also others from private institutions.

NUSESA has an estimated 1500 members in the various countries within the region. The national NUSESAs are organised in different manners, depending on a number of factors such as the competence involved, the support of national universities and institutes/organisations, the availability of funding, the interest of major donors etc. Although NUSESA is a regional network, its long-term sustainability depends on scientists and technicians working in the local context, in which the "equipment problems" are apparent. NUSESA countries are therefore encouraged to arrange local workshops and training courses at national levels.

4.1.3 Regional Activities

Since the start of the IFS programme, 13 regional workshops have been held. These workshops were for targeted for researchers and technicians from institutions depending on scientific instruments. The participants were taught how to operate and maintain their own equipment.

The topics included:

- The use and maintenance instruments.
- The use and maintenance of specific instruments e.g. pH Meters, Gas Chromatographs, High Performance Liquid Chromatographs, Atomic Absorption Spectrophotometers, Microscopes, etc.
- Basic electricity and electronics as background to the instrumentation
- Fabrication of pH Meter and Colorimeter
- Health and safety in laboratory
- Procurement and purchasing procedures
- Equipment selection.
- Laboratory management

An estimated 300 people have benefited from the training programmes, most of whom later became "trainers" themselves.

NUSESA held its first conference in December 2001 in Kampala in Uganda with the theme "Maintenance of Equipment for the Advancement of Science" and had over 100 delegates from all over Africa and beyond.

4.1.4. National Activities

The Regional workshops encouraged the starting of National workshops. People who attended the regional workshops, saw the value of training, and started the National workshops activities to train others. The local scientific equipment users formulated their own activities according to the local training needs. Workshops topics included:

- Information technology to cover computers, computer networking and interfacing,
- Vacuum technology
- Power supply and regulations
- Glass blowing
- Use of basic test equipment/tools
- Use and maintenance of various equipment and instruments

4.1.5.Individual Training

A number of people have been sent to other institutions for training through NUSESA. This included sending people for specialized training to South Africa, Britain, Taiwan, Nigeria, Cameroon and local institutions.

4.1.6 Spare Parts Fund

IFS made available a spare parts fund that helped put a lot of faulty equipment in the region back into working condition. The following institutions benefited from the programme:

University of Zimbabwe, Zimbabwe
University of Eduardo Mondlane, Mozambique
University of Dar es Salaam, Tanzania
Sokoine University, Tanzania
University of Malawi, Malawi
University of Zambia, Zambia

In 2002, the Netherlands Foreign Ministry revived the fund and gave NUSESA's support for the Spare Part Programme for a three-year period.

4.1.7. Funding of NUSESA activities.

From the start until 1999, NUSESA was heavily dependent on financing through IFS. IFS received funds from a number of donors for the equipment maintenance programme the majority of which came from SIDA (Swedish International Development Cooperation Agency). In 1998/99 SIDA/SAREC (Swedish International Development Cooperation Agency/Department of Research Cooperation) started to fund NUSESA directly. NUSESA has approached other donors for funds and currently has a grant from Netherlands Ministry of Foreign Affairs. However, the work to be covered is tremendous and NUSESA requires more funding and welcomes the support of all well wishes.

4.2.Results of Activities

In summary NUSESA has managed:

- To deepen the awareness regarding the necessities and conditions of equipment maintenance at universities and scientific institutions in the region
- To develop further knowledge and skills regarding maintenance strategies and organisation.
- To provide a forum to exchange experience on problems of equipment maintenance and to discuss ways of improvement.

One significant result is that in 1989 when NUSESA was started there were only five countries now there are 16 countries covering of the whole sub continent. NUSESA also managed to influence similar networks to start in other regions for example in Bangladesh and recently plans are underway for a network to be started in West Africa.

4.3. Future plans

The following is a summary of plans for the future for NUSESA:

- Carry out Needs Assessment activities to determine the current Needs and develop goals and strategies to address the equipment maintenance problems
- Once goals are set, prioritise and work out action plans or programmes in consultation with all stakeholders.
- Strengthen regional centre by seeking more support for the regional office so that it can actively, effectively assist the national centres, and actively bring to attention to the relevant people and authorities the issues on equipment maintenance.
- Develop databases of expertise, equipment, institutions and suppliers
- Develop and strengthen national nodes so that information can be passed around amongst members
- Address the issue of long-term sustainability for the organisation.

4. CONCLUSION

It is agreed that the equipment maintenance problems have to be addressed. As has been mentioned above many attempts by IFS, NUSESA and others have been made to

address the problems. These attempts have been significant. However, the problem of equipment maintenance is still with us. With the present status of our economies in our countries in the region, it is apparent that the problems might get worse. There is therefore a continuous need to address the problems continuously. The solutions are not easy and the problems will not be solved overnight. Commitment from all stakeholders is important in the success of addressing these problems.

It is also high time that Africa developed its own sustained technologies whose ownership is local so that local solutions can be found.

It is important that our administrators in our institutions and governments take seriously the issue of equipment maintenance. They have to be educated to place the issue of maintenance as a priority.

New projects with the provision of equipment should have a training component included and a provision for spare parts. Donors should insist of equipment policies from recipient institutions and assist where there are shortcomings. Technical staff should be given more recognition e.g. by consulting them during procurement procedures and by giving them the appropriate training.

It is important that the existing equipment structures be maintained and sustained. There is need to continue the support to the equipment maintenance centres. User training should be needs related and such training should be continued and supported. Since the manufacture of equipment is depended on developments in technology, it is important that users be kept abreast with the new developments through appropriate training courses.

No single group or single person has the monopoly of knowledge; it is therefore important that collaboration be encouraged among those trying to address the problems and equipment maintenance. In the end, we will only succeed if a majority of the relevant persons are fully aware of the importance of equipment maintenance.

Finally, the result with is progress in research and education in our institutions in Africa.

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