Research Report

Secondary pre-service teacher education in Ethiopia: Its Impact on Teachers' Competence and Confidence to Teach Practical Work in Science[1]

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Abstract: *The government of Ethiopia has espoused a practical problem-solving approach to teaching and learning science. The challenge facing the Ministry of Education is how to implement its objectives in a country which has been described as among the poorest in the World. The study reported here focuses on teacher education. It gives a description of science student-teachers' experience of pre-service education and the factors affecting their professional development with regard to practical work. It examines the structure of teacher education programmes, the content of the teacher-training curriculum and student-teachers' classroom practice in order to provide a fuller account of teacher education. The study advances this agenda further, revealing the practice of experienced teachers in schools. The conclusion uses the findings to propose ways in which the Ministry might implement changes to practice in initial teacher education to meet the objectives of the new reforms in Ethiopia.*

Introduction

Negash (1990) described science education in Ethiopia as being in crisis due to irrelevant and inappropriate methods which had failed to incorporate relevant practical experience. The present, post-1992 Ethiopian government has begun to develop science teaching as a process of enquiry and to look afresh at its methods of instruction. The new Education Policy and Sector Strategy (EMPDA 1994a, b) addresses issues, e.g. the purposes of science education, the context for the science curriculum, teacher education, and conditions that

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foster the development of practical work in school science. Accordingly, the primary science curriculum has been replaced, and a new secondary curriculum is to be phased in from the beginning of the millennium.

The Ministry of Education (ESDP 1997, 1998), recognizing that reform of school education requires concomitant reform in teacher-training, has redrafted the teacher education programme. Several studies suggest that teachers' views, understanding and practice, evolve from their own education and training. These experiences strongly influence not only what science is taught, but also how it is taught (Zelder and Lederman 1987, Tobin and Fraser 1988, Maskill 1995). The Ministry's attention to teacher-training is timely and well placed given that teachers are the ones who will implement the new curriculum with its intended emphasis on developing a practical, problem-solving approach to the science classroom.

The problem facing the Ministry is how to implement its objectives. The previous socialist and imperial governments both insisted that science was to be taught, at least partially, as a process of inquiry. However, science educators were not themselves trained in how to develop science skills and processes in their students, and a gap had grown between the curriculum intended by the policy makers and that taught in Ethiopian schools and colleges. Teachers and teacher educators have continued to employ purely didactic methods rather than introducing more appropriate instructional strategies necessary for the implementation of the new education policy: that is, a more thought-provoking, information processing and problem-solving approach' advocated in the new education policy, let alone in implementing it.

Notwithstanding the urgency of educational reform, there has been little time and opportunity for planners and curriculum developers to identify what was unsatisfactory in the old curriculum and what might be changed or modified to provide appropriate experiences in the new curriculum. Nor is it certain that teacher education institutions know how to modify their own pedagogy or that of their trainees to incorporate instructional strategies in the area of practical work in science. Thus, a reform of teacher education is looming without there appearing to be trainers with the necessary expertise to change the focus and methodology of the training.

One of the problems facing policy makers and trainers alike is that there is a degree of confusion inherent in conceptualizing practical work. There was an assumption among those whose contributions are reported here that practical work meant only laboratory work with relatively sophisticated, and imported, expensive apparatus. For instance, work done outside the laboratory or with locally available materials was not considered to be practical, but was viewed by many educators and the community at large to be low status activity (Bekalo 1997). The implication of this stereotypical view of the nature of science and its activities results in what Hodson (1996) refers to as the inappropriate use of practical work.

This is not the place to rehearse in detail arguments about the roles and purposes of different types of practical activities which are developed elsewhere (Hodson 1990, Allsop 1991, Hodson 1992, 1993, Woolnough 1994, Duggan and Gott 1995, Hodson 1996, White 1996). What is being discussed in this paper is a broad interpretation of practical work which promotes active learner participation in their own learning. This sometimes means 'hands-on', but also encompasses a range of other ways of working, including teacher-demonstration, group discussion of problems and their solutions, interaction between student and student, student and teacher, or student-teacher and pupil, student-teacher and trainer. It includes individual activity, e.g. measurement, observation and investigation. It can take different forms from experiments to pencil and paper activity, and take place in the laboratory, classroom or elsewhere.

Thus, not only has there to be a clarity in the definition of what constitutes practical activity, but also student-teachers and their trainers need to be clear about the roles and purposes of the range of practical opportunities which can be deployed to develop the sought-after problem-solving approach to science education in Ethiopia. This will be a difficult area for the reforms given the limited human and financial resources available in Ethiopia.

The study reported here gives a description of science student-teachers' experience of pre-service education and the factors affecting their professional development with regard to practical work. It examines the structure of teacher education programmes, the content of the teacher-training curriculum and student-teachers' classroom practice in order to provide a fuller account of teacher education. The study advances this agenda further, revealing the practice of experienced teachers in schools. The findings are from a year of research under-taken in teacher-training institutions and schools in Ethiopia. That research was concerned with factors influencing the place and development of practical work in secondary science (Bekalo 1997). The intent is to describe the influence of teacher-training on school practice at the present time and to reflect on ways forward to promote reform in teacher education.

Procedures and Methods

Secondary science teachers in Ethiopia are trained via a four-year BSc. degree course at University, or a two-year diploma course at teacher-training colleges following secondary school completion. Students undertake courses in academic science to increase their personal knowledge of the content of science, and in methodology to train them how to teach their subject. In this study, the physical science pre-service programmes of the two principal teacher-training colleges, referred to here as College A and College B, are examined to give an account of science student-teachers' experiences of pre-service education. The study examines the curriculum materials and classroom instruction strategies of the academic science and methodology courses in the colleges.

In order to establish the extent to which practical work was being fostered, course programmes, curriculum materials, assessment procedures and classroom practice were analysed. This was carried out in three stages which are presented in the same order in this paper. Firstly, the structure of both components – academic science and science teaching methodology – of the physical science programmes are described to show the emphasis given to the various components of the course. It should be noted that, apart from the general course outlines, there is no officially published teacher education curriculum in Ethiopia. Tutors devise instructional materials in current use. It is these materials which were made available for analysis.

Secondly, academic and methodology course materials were analysed to identify the types and purposes of the practical work in science they propose. The analysis was based on the classifications of practical work suggested by Gott et.al. (1998) who drew upon the assessment framework of the Assessment of Performance Unit's (APU) Science programme (Archenhold et. al. 1998). They are as follows.

- Basic skills: measurement, selecting and use of appropriate instruments, following instructions and the construction of tables, charts and graphs from data generated from students' experiments or drawn from other sources;

- Observation: observing similarities or differences and changes between objects and/or events, generating classifications of patterns;

- Illustration: showing (often through teachers' demonstration) given phenomena, concepts, laws or principles in action;

- Enquiry: 'discovering' a concept in a series of more or less structured activities, usually designed for students to carry out investigations following instructions to find out, confirm or 'see' a concept in action;

- Investigation: designing and carrying out an entire investigation which includes examining the data of the investigation and drawing conclusions from them.

Two procedures were used to analyse the curriculum materials and texts. In the first procedure, practical activities were identified and then classified into the various categories above. Each activity was noted on a grid to estimate the frequency of use of each type of activity. In the second procedure, the purposes of each task were carefully examined in terms of instruction and for the consistency with which experiences were provided in line with the statements of objectives in the curriculum. A matrix thus provided a summary of tasks, task types and purposes of the tasks.

The same analysis scheme was applied to examination papers allowing comparison of the achievement of objectives in the intended curriculum as presented in texts and associated materials with that taking place in the classroom (see below) and that tested in the examination systems.

Thirdly, course implementation was examined through analysis of classroom observations. The research focus and timetable of the research programme allowed for observation of a total of 40 lessons in the two training colleges. The selection of year groups, laboratory and methodology sessions, teachers and trainers, although constrained by the college timetable, has allowed portrayal of a full picture of the practices of science teacher-training.

Two classroom observation schedules, referred to here as Record Sheet I and Record Sheet II were developed to record the lessons and to facilitate their analysis. The nature of practical activity recorded on Record Sheet I was based on a modified form of the classification of Gott et. al. (1988) described above. Where no practical activity took place, Record Sheet II was used, a modification of the categorical system of Flanders known as FIAC (Flanders 1970) where teacher-pupil interactions were recorded at 3-min intervals. FIAC uses a 3-s interval, but the pilot study confirmed that student activity in the college visited was largely limited to listening and note-taking. The methods thus allowed the recording and development of descriptions of the types, purposes and frequency of observed tasks and activities, the organization of the task, teachers' and students' roles, and the materials in use. This has allowed a full account of the classroom. Furthermore, assessment procedures were looked at while discussions with tutors and student-teachers conducted after each observation enriched the data on teacher-training practice.

The results reported in the following sections are intended to give an insight into teachers' initial training, their professional development and the factors influencing that development with regard to practical science.

Results and Discussion

The Initial Teacher Education Programme for Physical Science

Secondary teacher education leading to a teaching certificate, diploma or degree, is similar throughout the higher education institutions of the country and consists of two parts.

- Academic courses which include laboratory sessions in the major disciplines in which students are being prepared, academic courses in the minor disciplines students are likely to teach, and common courses, e.g. psychology and philosophy;

- Methodology courses in both major and minor subjects as well as courses described as general methodology.

Figure 1 below presents the chemistry and physics course structures at the selected colleges. These two courses are chosen to show coverage within the initial teacher education programme.

As can be seen from allocated credit hours in figure 1, the theoretical academic courses, in both major and related areas, carry the most emphasis. The laboratory centered academic courses occupy the least amount of time. It is worth noting, however, that the number of credit hours does not always correspond with the number of contract hours (e.g practical organic chemistry with 1 credit hour has 3 contact hours).

Subject methodology courses, including perhaps surprisingly teaching practice, are also less prominent. It was clear from interviews of staff and students that courses with low credit hours did not seem to be taken seriously by student teachers or their trainers, partly because they counted little towards the grading or promotion of students. This is discussed within the analysis of classroom practice presented later.

The Content of Laboratory Practical and Methodology Courses

As stated earlier, there is no officially published teacher education curriculum. Instructional materials currently used were devised by individual teacher-trainers. They were largely a modification of the academic university curriculum intended for use in producing pure physical science graduates rather than teachers of the physical sciences.

To give the reader a feel for the nature of these course materials, a sample of laboratory-centred academic and methodology course contents for use in preparing teachers is presented in figure 2.

The academic, laboratory-centred component specifies practical activities, e.g. investigation and analysis, and at first sight this is an encouraging sign that prospective teachers are being prepared to develop active, investigative approaches to practical work in school science.

Course Categories	College A Chemistry Course Title	Cr. Hrs	College B Physics Course Title	Cr. Hrs
Academic				
Major subject area courses (theoretical)	General Chemistry	4	General Physics I	4
	Inorganic Chemistry I	3	General Physics II	4
	Inorganic Chemistry II	3	Mechanics	3
	Organic Chemistry I	3	Electricity and Magnetism	3
	Organic Chemistry II	3	Introduction to Modern Physics	2
	Physical Chemistry	3	Basic Electronics	2
	Analytical Chemistry I	1	Heat and Thermodynamics	2
	Analytical Chemistry II	1	Optics	2
Major Subject area courses **(laboratory centred)**	Practical Inorganic Chemistry I	1	Experimental Physics I	1
	Practical Inorganic Chemistry II	1	Experimental Physics II	1
	Practical Organic Chemistry I	1		
	Practical Organic Chemistry II	1		
Major subject area courses (theoretical)	General Physics I	4	General Chemistry	
	General Physics II	4	Freshman Mathematics	4
	Basic Mathematics	4	Applied Mathematics	4
	Freshman Mathematics			4
Common Courses	English for Special Purposes	2	Preliminary Mathematics	4
	Political Economy I	2	Freshman English I	3
	Political Economy II	2	Freshman English II	3
	Psychology of Human Development	2	Introduction to Geography of Ethiopia	3
	Health and Physical Education I	1	Introduction to History of Ethiopia	3
	Health and Physical Education II	1	Introduction to Economics	3
	Health Education	2	Introduction to Philosophy	3
			Introduction to Psychology	2
			Development Psychology	2
Methodology Subject Oriented	Chemistry Teaching Method	2	Subject Methodology	2
	Methods of Teaching Chemistry	2	Teaching Practice	2
	Methods of Teaching Physics	2		
	Teaching Practice	2		
General	General Methodology	3	General Methodology	3
	Instructional Materials	2		
	Measurement and Evaluation	2		

Figure 1. Structure of programmes of study for a diploma in chemistry and physics at the selected colleges

Course Title		Contents
2.1 Laboratory centred practical course for chemistry/physics		
Practical analytical chemistry	Systematic qualitative analysis of the anions and cations	- reaction of group I, IIA, IIB, III, IV, V and VI cations - analysis of group I metals, group II A cations, groups II & VI metals - separation of the metals, separation of group II cations into group IIA and group IIB, separation of group IV & group VI cations - detection of anions and volatile, oxidising anions, sulphate group anions
Practical organic chemistry	Techniques in experimental organic chemistry and simple organic preparations	- simple distillation, fractional distillation, steam distillation - recrystalisation, chromatography, stereo chemistry - preparation and properties of aspirin and oil of wintergreen and soap - qualitative organic analysis
Experimental physics I	Experiment in general physics heat, mechanics, optics	- analysis of simple harmonic motion (SHM) - Archimedes' principle, Newton's law of cooling,, specific heat of solid
Experimental physics II	Experiment in general physics construction and investigation of electrical devises and circuits	- converting galvanometer for use as a Voltmeter, as an Ammeter - investigation on the transformer, variation of potential difference (p.d) of dry cell; investigation of transistor characteristics - measurement of internal resistance and electromotive force (emf), resistivity of a metal by half-meter bridge - characteristics of junction diode and Zener diode - determination of specific charge of electron (e/m) by magnetic induction
2.2 Subject methodology for chemistry/physics	-objectives of teaching chemistry/ physics - the subject matter in teaching chemistry/physics and their contexts - the instructional process in teaching chemistry/physics	- the aims of teaching science - planning lesson unit, chapter, particular topic - teaching process (textbook, curricula materials, personality), evaluation - methods of experiment in science instruction, basic rules and steps for carrying out experiment, experiment to verify facts - demonstration method, project work method
2.3 Teaching practice	- identification of students' ability in the application of educational theories and principles in actual classrooms situations in teaching specific subject in the secondary schools	- observation of actual teaching lessons in schools, micro teaching, planning - subject unit lesson, preparing and carrying out lessons

Figure 2. A sample outline for course contents from the College instructional materials

However, while there might appear to be an orientation towards practical investigation, we saw no such work during or outside the scheduled hours in the laboratories at the university or colleges studied. The laboratory manuals themselves focus on the acquisition of 'known or existing' science facts through routine procedures. The aim of the practical activities seemed to be get the 'right answer' by following detailed routine instructions, rather than on the development of investigative approaches. This could be seen from the format of the (identical) laboratory activity manuals used by the two teachers' colleges. These manuals specified the following.

- Title of experiment;
- Objective (e.g. to investigate, observe, analyse, measure confirm given tasks);
- Chemicals and equipment required;
- Theory (description of the underlying theory and/or properties of substances involved in the experiment):
- Procedures (occasionally table and graph formats to record results also offered); and
- Results.

The available chemistry and physics laboratory manuals were examined (KCTE 1994b, c, BTC 1994a, b). In all cases, the problems, experimental instructions and intended outcomes were provided for the students. Terms like 'analyse' and 'investigate' were used in the manuals, but students were not required to define the problems operationally, to proceed through tasks effectively, to evaluate evidence and to draw and communicate conclusions. To make the point clearer, the following, a typical example from one manual, is shown in outline in figure 3.

Experiment 8.3: Vibratory Motion

Objective: To analyse simple harmonic motion (SHM)
Apparatus: The necessary apparatus was listed.

Theory: Describes harmonic motion. It then outlines the relationship between displacement, velocity and acceleration of a body executing SHM followed by mathematical equation. Finally, it explains one of the most common examples of SHM – the motion of a pendulum.

Procedure: Attach a long piece of thread, about 2 metres long to the pendulum bob.

Measure the length of the pendulum 1 and then set the bob in oscillation through a small angle. Time 20 complete vibrations.

Change the length of the pendulum shortening it by 10 cm each time repeat this procedure 15 times.

Plot a graph of m versus T^2 and from the graph calculate the average gravitational acceleration g at your campus.

Record your results in the table below

	Length 1 in cm	Time t in sec	T in secs	T2 in sec2
1				
2				
3				

Results: If (amplitude of the pendulum) is small, the motion of the pendulum can be considered as SHM and its period can be mathematically presented as $T = 2\pi$ root of 1/g. This shows that the period of the pendulum depends only upon the length of the pendulum and the acceleration due to gravity. The period is independent of mass. The period is also independent of the amplitude when the amplitude when the amplitude is very small.

Figure 3. Extract from College A Physics Laboratory Manual

Such practical activities were perceived by both parties (i.e. tutors and their students) as routine activities for arriving at a predetermined solution following detailed instructions.

Further evidence of practice supporting such perceptions came from the way student-teachers' practical abilities were assessed at the end of the course.

For the practical examination, the apparatus for a number of practical activities conducted during the course was laid out on a table. The test papers were presented face down and students picked one of the papers at random. This gave them the title and objective of the experiment which they proceeded to carry out without using laboratory manuals, thus recalling procedures to arrive at expected outcomes.

Methods of Teaching Physics (Phys. 172)	
Units	Sub-contents of Unit 1
1. Objectives and tasks of physics instruction	1.1 Inductive method
2. The content of physics instruction	1.2 Deductive method
3. The cognition process in physics instruction	1.3 The model method (e.g. particle model, field line model, globe, model of earth/sum)
4. Realisation of didactic function	1.4 Methods of experiment in physics instruction (e.g. teacher demonstration, student experiment)
5. Planning of instructional process	
6. Typical situation in physics instructions	1.5 Basic rules for carrying out experimental work
7. Teaching aids	

Figure 4. A sample of physics methodology course content and class-room practice at College A.

Subject methodology courses specified practical activities as figure 3 shows. Figure 4 is an example of the typical content and suggested classroom practice of a unit in the physics methodology course offered at College A.

The Methods of Teaching Physics course suggests that practical work will be done. Close scrutiny of tutors' handouts and student-teachers' notes suggested that methodology courses did not include hands-on practical work and none was seen in either college over the period of observation. The observation notes made while the teaching of the unit described in figure 4 above was taking place state:

> No practical activities were observed. All the headings/content of unit 1 were covered by the tutor. He gave dictation on definitions of inductive method and so on and followed with a lecture on the contemporary teaching methods.

The analysis of classroom observations is presented in the next section to describe teachers' and students' actions during the time scheduled for laboratory practical and methodology sessions.

Classroom Practices in the Teacher-Training Colleges

A total of 40 lessons (20 laboratory sessions and 20 pedagogical sessions) in the two teachers' colleges were observed. Laboratory sessions refer here to academic physics and chemistry practical course sessions. Pedagogical activities refer to subject-oriented and general methodology courses where some sessions included teaching practice.

During the study in the teachers' colleges, science classes were observed to be small, always fewer than 20 students. Each of the observed colleges had separate laboratories for physics, chemistry and biology. These colleges had basic equipment and materials to support practical work for groups of this size in their science and methodology courses.

Laboratory Sessions

In all laboratory sessions, practical activities were organized for students and more usually conducted by laboratory assistants than academic tutors, perhaps indicating that such activities were seen to be of low status. The main features of classroom organization and transaction can be summarized as follows.

Tutors/laboratory Assistants

- Set up the apparatus and provided equipment;
- Explained the underlying theory and the procedure to be followed;
- Divided students into groups (usually into four or five);
- Walked around to check students were following the prescribed procedures;
- Assisted with using the apparatus;

- Collected and corrected laboratory reports.

Student-teachers

- Performed assigned tasks according to the lab. format
- Produced laboratory reports

The major form of verbal exchange between all involved related to the precision with which the procedures were to be followed, the expected answers to be obtained and the underlying theory to be confirmed. Student-teachers' main anxiety was about how close their experimental results were to the 'right' answer, and it was noted that they often altered their data to match this expected answer.

This practice was evident also in their laboratory reports. On five different occasions, a copy of the raw data of different groups was collected immediately after the sessions, for comparison with their final report which they submitted later. This scrutiny revealed significant modification of the original raw data in all the final reports. This observation was supported by discussions with tutors who acknowledged that they were aware of alterations. It seemed that the tutors' main concern was more whether students followed the standard laboratory procedures and presented the report neatly than with making sense of real data. At no time did students or their tutors attempt to explain anomalous results.

Although the laboratory practical activities gave students first-hand experience of scientific phenomena, the opportunity was seldom observed to have been taken to develop their procedural understanding. Tasks involving more open investigation were not observed. Courses were not organized in ways which gave students the opportunity to set up and carry out practical activities for themselves, or indeed, as described in the next section, how to assist school pupils with practical activities. The purpose was solely to support students' acquisition of knowledge of content in the disciplines being studied.

Methodology Sessions

Student-teachers were introduced to discipline-specific and general methodology through courses which included teaching practice in the two-year programme. A total of 20 methodology sessions was observed during this study in order to describe how trainees were prepared to teach science and whether such training included instruction on how to teach practical work.

No practical activity was observed in any of the sessions visited. Tutors lectured about the advantages and disadvantages of a range of contemporary teaching methods, e.g. the use of demonstration, learning by inquiry and project-based work. The sessions did not involve students in any kind of practical activity, not even group-based discussion of the practices they would be expected to carry out in classes. There was no explicit instruction on how to organize practical work in the school science classroom.

Students were never required to plan or model how to carry out a range of modes of teaching in various situations. Often, the general methodology courses were taught in a lecture theatre to large groups of science and non-science students gathered from different departments. Methodological courses were put into operation by the tutors and course organizers as purely theoretical and expository.

Similarly, the teaching practices which students completed in schools did not include practical work in science. Both colleges used the same teaching practice evaluation form illustrated in figure 5.

The form covers most of the predicted components of lessons, but it could be for any lesson in any subject. It lacks specificity and nowhere offers criteria for evaluating a student's ability to organize a class to carry out practical work or other science learning activities. Students did not teach pupils how to do practical work in science and teaching practice assessors were not expected to judge this ability in their student-teachers. Cause and effect are not being judged here, but students were unlikely to have included practical sessions in science if it did not have sufficiently high status to be part of an evaluation of their teaching competence.

It is apparent that trainees were not given the opportunity to think about the issues and purposes of different types of practical work, the complexities of various instructional strategies or methods of implementation and assessment. In the light of the lack of practical input about organizing science practical work during initial training, it would be surprising if experienced teachers themselves were skilled in introducing their pupils to practical activity in schools. Examination of this premise forms the next section of this paper.

No.	Items	Maximum	Given
1	Personality, Use of Voice, Command of Language	10	
2	Class Management, Relationship with Pupils	10	
3	Presentation/Accuracy of Exposition/Factual Accuracy	10	
4	Preparation of Lesson Plan	15	
5	Effective Use of Chalk Board Effective Use of Teaching Aids	10	
6.	Application of Different Teaching Techniques Pupils' Participation, Summary, Feedback	20	
7	Unit Plan (once at the beginning) Test (once at the end)	5 10	

Supervisor's Comments:

a. Strong points ....
b. Weak points ....
c. Suggested recommendations ....

Results:	Evaluation I: --------- (out of 95)	Item 7: ------- (out of 15)
	Evaluation II: --------- (out of 95)	Total: -------- (out of 300)
	Evaluation III: -------- (out of 95)	Letter Grade: --------------

Supervisor's Name ------------------ Signature ------------- Date -----------

Figure 5. Teaching Practice Evaluation Form

Classroom Practice in the Schools

In spite of the policy intention to make science relevant, practical and suitable for the majority of people (e.g. MOE 1984), much of the science taught in Ethiopia remains very much concerned with rote learning of factual knowledge and the passing of examinations predominately valuing recall of knowledge.

The field study in Ethiopia reported here used a variety of sources of information about practices in schools, including curriculum documents, extensive classroom observation and interviews of teachers (Bekalo 1977).

Only once during the 80 science lessons observed in four secondary schools was practical science activity seen, and this was a practical demonstration by the teacher. As many of the educators interviewed agreed, practical work hardly ever takes place in Ethiopian secondary science classrooms.

This lack of coherence between intention, implementation and evaluation of the educational programme is not, however, unique to Ethiopia. A number of other studies have reached similar conclusions. The relationship between the official and transacted curricula in many African countries is characterized by many forms of mismatch (Yager 1984, King 1986, Olorundare 1990, Peacock 1995). Factors, e.g. poor physical settings of schools, large class size, lengthy syllabus and inappropriate time allocation, as well as inadequate pre-service and in-service teacher-training, have all been identified as inhibiting the use and development of practical work (e.g. Allsop 1001, Bekalo 1997).

Despite the acuteness of such problems in Ethiopian secondary school science, the extensive classroom observations of this study would suggest that lack of equipment and resources is not always the cause of failure to do practical work. Sometimes in schools and invariably in the teacher colleges, opportunities for practical work were not always restricted because of lack of equipment. As already remarked, colleges were reasonably resourced and had class sizes of around 20. Also, one of the sample schools had fewer than 20 students per class and reasonable resources, yet teachers were never to be observed teaching using practical work.

Paradoxically almost, many of the teachers in that school perceived the crowded urban school classes with more than 60 students, which they had experienced as pupils themselves, to be normal and stated that they were not motivated by the relatively quiet atmosphere of small classes. When pressed on this point, they did not know how to use small classes to their advantage, for example, for science practical activity. Classrooms are complex and variable places, but it would appear that the Ethiopian teachers observed were not flexible or knowledgeable enough to exploit favourable conditions and so provide children with practical experience.

Inappropriate teacher education was seen by many of the educators interviewed as a major problem facing the nation as it sought to implement the intended curriculum. Several teachers and teacher-trainers felt that the teacher-training courses were inadequate, not only with regard to practical work, but also felt that teacher-training lacked congruence with both the school curriculum and the realities of the typical classrooms.

Reflecting on this, a teacher-trainer said:

> Most of us here are pure physics, chemistry, biology graduates from Addis Ababa University. We took a few educational methodology courses at university, but that is not enough and we can't say we are educators. Because of our background our college courses are highly influenced by the university course we brought with us. You can compare the contents yourself. On the contrary, we do not relate the content to the school curriculum and I have never even seen any school curriculum materials working here for years. I think there is a clash between what we teach and the objective of the college.

A school teacher said:

> In college we didn't refer to secondary science textbooks and we were not taught how to use them; particularly the experimental activities. In fact, we did some experiments in college but what we did was what our tutor told us to do. When we come to schools there is no guidance from tutors and it is difficult to start the experiment from scratch on our own. If we were taught how to start and finish the experiment we would not have such a problem.

College courses were not organized in ways in which the trainees could learn how to set up and carry out practical activities, how to assist school pupils to develop conceptual and procedural knowledge in typical classrooms, or given any practice which would assist them in translating the training course into school-based activity.

In general, small classes, basic apparatus in the laboratory and a laboratory assistant notwithstanding, teachers were not observed to conduct the demonstration experiments recommended by the syllabus. Instead, they were only observed lecturing in order to convey knowledge about the concepts of science, occasionally mentioning practical activities which might illustrate or make phenomena real. From this practice, it is not unreasonable to suppose that the chalk and talk and routinized guided-experiment approaches, persistently employed by Ethiopian teacher-trainers, inevitably affect the competence of teachers to carry out practical work confidently and independently.

Conclusions and Issues for Teacher Education Development

It is apparent that the two dimensions of academic and pedagogical content in teacher-training in Ethiopia are not given comparable credit or attention. 'Pedagogical content knowledge' (Shulman 1986, 1987) is not seriously considered. It is somehow ironic that in teacher-training institutions, where one might expect a focus on pedagogy and pedagogical methods, one encounters instead a devotion to academic study with little attention given to pedagogical study, and the practise reflects little application of pedagogical knowledge.

Turning to teacher-training for physical science specifically, although academic courses incorporated routine laboratory practical activities, the planning and carrying out of practical work and the assessment of abilities in practical work were completely neglected. Perhaps this is because teacher educators did not recognize practical work as being other than routine procedures involving the following of instructions to arrive at predetermined problem solutions.

An alternative, if less charitable explanation, is that the tutors themselves did not have the necessary practical skills to organize, carry out and evaluate investigative science activities. Whatever the situation, trainees were not taught how to think through the issues of investigative science. They were not exposed to thinking about the purposes of practical work and the complexities of instruction, implementation and assessment. It is not surprising, therefore, that teachers do not attempt practical work in schools even when there are conducive classroom settings and reasonable resources. They do not know how too!

There is a need to review the structure and system of teacher education in order to increase the expertise of graduating students. As noted earlier, the present government, recognizing the inadequacy of teacher education, called for a review of the teacher education programme in order to promote teachers' professionalism in teaching contextualized practical science. We suggest when engaging in the forward-looking task of restructuring and developing teacher education programmes, those charged with the reform should consider the present teacher-training situation exposed by this study.

Balancing Curriculum Load and the Credit Given to Academic and Pedagogy Courses

The curriculum as presently constituted does not give equal weighting and allowance to academic and pedagogical study, resulting in lack of motivation and interest associated with the low-credit method courses. Programme reviewers might need to consider how to ease the curriculum load and adjust weightings to value both the academic subject and pedagogical disciplines. The teacher education programme might wish to build on what Shulman (1986, 1987) has referred to as 'content knowledge', 'pedagogical content knowledge' and 'pedagogical knowledge'.

Broadening the Scope of Practical Work

Presently there is an association, in science teachers' minds at least, of practical work only with laboratory work involving sophisticated and expensive apparatus and equipment beyond the resource capabilities of the country. The practical emphasis is on illustrating phenomena involving taught concepts where useful experiments may well require such high cost equipment, rather than on assisting the exploration of phenomena where conceptual and procedural knowledge may be developed using simpler apparatus. This existing emphasis restricts the range of possible strategies available for promoting practical work and providing a variety of learning experiences in a wider context.

Curriculum planners might identify practical work as more than simply experimental work in the laboratory and promote a conceptualization to include activity that could take place in the laboratory, classroom or elsewhere. Practical activities should be considered in terms of their appropriateness in providing a wide range of knowledge and experience and their compatibility with typical Ethiopian classrooms.

Emphasis on School Curriculum and Settings

The present practice of pre-service training reflects little on the school curriculum or on what student-teachers may be called to do upon their appointment to school, especially in the area of practical work in science. It is appropriate to promote the idea that pre-service education should serve as a model for the kinds of teaching and learning activity newly qualified teachers might be expected to practise.

This would suggest that detailed and integrated understanding of educational settings, curricula and instructional methods of school and teacher education is essential so that the developers consider and develop alternative approaches using locally available resources, the environment and indigenous technology as a resource for science teaching and learning. Such approaches are in danger of being seen as 'second class', because they do not require the expensive equipment available to schools in the North and West. In response, many studies have shown that, if well thought-out and planned, it is possible to carry out excellent science with locally available low/no cost resources and that pupils following such courses achieve enviable levels of scientific knowledge and understanding (e.g. Knamiller 1994a, b, 1989, Zim-Sci 1987, Bekele et al. 1990, Macdonald and Rogan 1990, Towse 1997).

Examinations and Assessment

The skills which characterize the nature of scientific and pedagogical activities cannot be fully tested by the present form of examination which tests recall almost exclusively. Test programmes worldwide have shown that valid items can be written which can be used to broaden the scope of the science tested without losing test reliability (see, e.g. Archenhold 1988, Keys et al. 1996).

The assessment of both academic and pedagogical courses including teaching practice, would require modification in order to test student competence over a wide range of practical skills. The teacher education programme would then have to place greater emphasis on the relationship between learning and assessment.

Enhancing Educators' Competence

Planning and implementing such teacher education programmes requires effort from competent educators. Teacher-training institutions would be required to review and develop their staff specialisms to plan and implement a programme to provide a firm foundation in relevant new approaches and techniques for trainees and teachers in schools. However, until the professional capabilities of those with responsibility for developing the training programme are expanded and those educators empowered, meaningful change will not occur (Weiss 1995).

In summary, this review of practice in two of Ethiopia's teacher-training institutions has identified the challenges ahead for those who are involved in the development of teacher education in Ethiopia. The messages might strike resonances with others embarking on a similar enterprise elsewhere.

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