PILOT INTRODUCTION OF SMALL-SCALE CHEMISTRY KITS INTO TWO ETHIOPIAN SECONDARY SCHOOLS

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ABSTRACT

In this study we used small-scale chemistry kits (MYLAB) in order to promote small-scale experiments as a pilot project in two Ethiopian secondary schools. Laboratory conditions and experimental practices were assessed by interviews with the school principals and questionnaires to grade 10 students and the chemistry teachers. The teachers were given a hands-on training. Experimental and control group of students were selected based on their grade 9 chemistry performances. Both groups were given a pre-lab talk; thereafter experimental group students conducted the experiments. The laboratory condition assessment revealed problems with chemicals, equipment, apparatus, electric installation, running water and technically-trained staff. The introduction of the kit into the schools and the hands-on training were considered a great achievement by the school principals and the teachers in alleviating the problems of chemistry practicals in the schools. *[African Journal of Chemical Education—AJCE 9(3), November 2019]*

INTRODUCTION

Every science learner should have practical scientific experiences. However, the reality in most Ethiopian schools involves learning sciences through pictures in books, drawings on the blackboard and questions in examinations. The gap between ideal learning and the real situation is basically due to shortages in budget, laboratories, equipment, chemicals, and the problems related to repairs and maintenance. These problems could be alleviated using the small-scale approach because experiments are in a small-scale.

The chemical education in Ethiopia is not up to the level expected. One of the many possible reasons is inability to do practical activities in the primary and secondary schools syllabi. Therefore, this study aimed at making use of small-scale chemistry kits (MYLAB) in order to alleviate the long-standing problems of chemistry practicals in two secondary schools.

The study was conducted in Dilla and Wenago secondary schools, which are situated South of Hawassa, the capital of South Nations and Nationalities Peoples Region (SNNPR), Gedeo Zone, Ethiopia. The schools were selected on the basis of proximity to the researchers' residence, the school type and standard.

LITERATURE REVIEW

It is not realistic to think about effective chemistry education without including experimentation. As Bradley (2001) asserts, the following quote reflects a universal opinion and expectation: "Chemistry is fundamentally an experimental subject … education in chemistry must have an ineluctable experimental component" [1]. However, for years, the very high cost of constructing and equipping laboratories has prompted many schools and even some universities in Africa to adopt a theoretical approach to science teaching [2]. The concept of small-scale science kits appears to have been conceptualized in 1993 by the RADMASTE center (Centre for Research and Development in Mathematics, Science and Technology Education) of the University of the Witwatersrand in Johannesburg, South Africa [2]. "The underlying assumption of small-scale chemistry experimentation is less is more: less costs, less demand on chemicals and equipment, less 'chalk and talk' teaching, for more understanding, more motivation, more safety, and more 'hands-on and minds-on' learning activities" [3].

Small-scale chemistry refers to an approach or technique for carrying out experiments on a reduced scale using small quantities of chemicals and often with simple equipment [4-5]. Small-scale chemistry involves scaling down of chemical reagents to the minimum rather than those used in traditional laboratories; and shifting from glassware to modern polymer or plastic materials [6].

The concept of small-scale chemistry was introduced to many African countries through workshops. The workshop is usually conducted in such a way that a hands-on experience is interspersed with discussions. On top of that a videotape demonstration is usually included. As Bradley pointed out, in workshops teachers smiled, and kept on smiling to the end and found students smiling while conducting small-scale experiments in the classrooms [7]. In South Africa the small-scale science concept found its way into many different workshops. The impact was consistently positive, everyone succeeded in using the new small-scale equipment. Furthermore, a majority of students were able to experience chemistry firsthand as the need for a traditional laboratory was removed and chemistry education might be revolutionized worldwide. It was therefore considered by school teachers, science inspectors and a few university lecturers as a promising solution to the problem of practical work provision [8].

METHOD

This small-scale study included three phases. The first included a context analysis and a literature review. The context analysis was meant for gaining insight into the practical teaching and learning chemistry in the two secondary schools with more emphasis to implementation challenges. The literature review aimed at gaining insights into small-scale chemistry as a promising example of low-cost methods for promoting practical work in chemistry teaching. The second phase involved development of small-scale chemistry experimentation student's worksheet and testing out its feasibility. The third phase of the study was focused on the hands-on training of the teachers and the introduction of the small-scale (MYLAB) kits into the selected secondary schools.

Participants and setting

80 grade 10 students (40 experimental and 40 control groups) were selected for this study, in the schools. However, the number of students who replied to the questionnaires was only 31 and those who answered were all from the experimental group. The number of students participating throughout the course of the study was 43 (22 from control and 21 from experimental group). Of these 25 were male and 18 were female, aged between 15-18 years. The technique used to select students was a purposive sampling method. As the study was a pilot, two groups (experimental & control) in each of the two schools were organized. Students were selected for the two groups on the basis of their grade 9 chemistry performances such that 5 students had scored below 50% (slow learners), 10 students in the range 50-70% (average students) and the remaining 5 students in the range 71-100% (fast learners) in grade 9 chemistry subject. Pre-laboratory talks were given to experimental & control groups equally by the researchers for each experiment.

Students in the experimental group conducted the experiments under the guidance of the researchers and the school chemistry teachers.

Two secondary schools in Dilla and Wenago towns were selected on the basis of proximity to the researchers' residence, the school type and standard. Wenago secondary school is a typical government school whereas Donbosco secondary school is a private (Catholic Church) school and is of better standard.

All chemistry teachers (3 from Wenago and 1 from Donbosco) and the school principals of the two schools participated in the study. All teachers were male with teaching experiences (at the currently working schools) ranging from 1 to 10 years and total teaching experiences ranging from 6 to 16 years. All teachers in Wenago had bachelor of education degrees in chemistry whereas the teacher in Donbosco had an MSc degree in chemistry. A three days hands-on training was given for all four of them.

Instruments

Instruments of data collection included questionnaires, interviews, quizzes, checklists, assessment of grade 10 chemistry textbook & school laboratory, and focused group discussions. Separate questionnaires containing open- and close-ended questions were prepared for chemistry teachers and the grade 10 students (experimental groups), in order to gain insight into the practical teaching and learning of chemistry in the schools, with an emphasis on implementation challenges. Unstructured interviews were prepared for the school principals. The same types of quizzes were given (for both groups) before the pre-laboratory talk in order to examine the impact of small-scale chemistry approach on students' cognitive learning. Students in the experimental groups were made to make a self-evaluation on the various aspects of the experiments, by using the checklist from the MYLAB kit. A grade 10 chemistry textbook (2010 edition) was assessed and a student's worksheet for each of the 16 small-scale experiments prepared for use with the MYLAB kits. The feasibility of the experiments in the worksheet was tested twice by the researchers, and amendments were made accordingly. The schools' laboratory conditions were also assessed by the researchers. Separate discussions were made before (on the purpose and aim of the study and the roles of participants) and after introduction of the kits (on the reactions and opinions) into the schools with grade 10 students, chemistry teachers and school principals.

The students' data (from questionnaire) were converted into percentile and discussed and the results were briefly presented. Data from the school principals' interviews, researchers' laboratory assessments and discussions with students, chemistry teachers and school principals were analyzed qualitatively. Data obtained from the teachers' questionnaires were analyzed quantitatively as well as qualitatively.

RESULTS AND DISCUSSION

First Round Discussion with Students

A 30 minutes' discussion was made with the students in each school on the purpose of the project and their roles therein. Some issues raised by the students were: what would be their benefits from the project, if the marks they were scoring on the quizzes were to be part of the total mark or not, and whether the control group could be allowed to do the experiments somehow? To these issues we explained the benefits they could get by doing the experiments and that we would give prizes for the first three high scoring students in both groups. The control group students were promised to be allowed to do the experiments after the experimental group students had completed them. The idea of giving certificates for the active participants in the project came from students' side and was a novel idea. Otherwise all we did was trying to help them understand the short and long term benefits of the study in their schools in particular, and at the national level in general. After the discussions students came to a consensus to participate in the study.

Students' Questionnaire

Only one student in Donbosco School did not get the opportunity to do or demonstrate experiments in the various grade levels up until grade 10 (Table 1). The reason given by the student was lack of the necessary chemicals and apparatus in the school laboratory.

Table 1 Responses given by students to the questionnaire

No	Question	Response	Respondents (Donbosco)		Respondents (Wenago)	
			Number	%	%	Number
1	How much do you like learning chemistry subject?	Very much	7	41.2	57	8
		I like it	4	23.5	28	4
		Fairly	6	35.3	15	2
		Very little	0	0	0	0
		I don't like it	0	0	0	0
2	Is there functional laboratory in your school?	Yes there is	17	100	0	0
		No there isn't	0	0	78	11
		I don't know	0	0	22	3
3	If you have functional laboratory in your school, have you done some experiments from the grade 10 chemistry textbook?	Yes I do	17	100	0	0
		No I don't	0	0	100	14
4	Has your chemistry teacher done or made you do experiment(s) in the classroom?	Yes he/she did	13	76	0	0
		No he/she didn't	4	24	100	14
5	Has your chemistry teacher demonstrated (for you) or made	Yes he/she has done and made me do	16	94	71	10

you do experiments at any grade level in the school(s) you have attended up until grade 10?	No, he/she neither did nor made me do	1	6	0	0
	I don't remember	0	0	20	3

The experience in Donbosco School in relation to students' intake was that most of the students came from the second-cycle (grade 8) of the same (catholic) school. Very few students join the school from neighboring government schools. On the other hand, students in Wenago School came from the various second-cycle schools in Wenago town or the surrounding areas, where the possibility of having functional laboratories is almost nil.

Second Round Discussion with Students

A 20 minutes' discussion was made in order to evaluate the students' reactions to their results and to the MYLAB kits. All of them agreed on the usefulness of the kit in helping them get better chemistry practicals. Most of the students were pleased on getting the opportunity of not only looking but actually for doing experiments. They did not deny the fact that handling the small-scale apparatuses was very challenging. The second challenge was lack of time to come to school only for this purpose (Wenago School). All of them were happy for having conducted 15 experiments, which would otherwise have been impossible.

First Round Discussion with Chemistry Teachers

Discussions with teachers were made in the schools on the aim and their roles in the project. Information on each of the three days of hands-on small-scale training was also given. After the discussion, the teachers agreed to participate in the study.

Teachers' Questionnaire

In Wenago school there appears to be no building for laboratory purpose. In addition, getting chemicals for grade 10 chemistry experiments is a particular problem. The reasons mentioned were that no attention was given to procuring chemicals because the laboratory is non-functional, as well as that the cost of chemicals is high and the school does not have enough budget to buy these.

In Donbosco School many of the chemicals already available in the laboratory were not for the experimental activities in grade 10 chemistry and this was one explanation for not having conducted more than 41-60% of the experiments in the grade 10 textbook. Another reason for not having completed more experiments in Donbosco was that, at the time the questionnaire was collected, only half of the school year had elapsed.

Except for one teacher in Wenago, all teachers agreed on the inability of doing experiments in the classroom as the experiments were designed in such a way that they could only be done in a laboratory. However, the agreement on the presence of many experiments that could be done in the classrooms by the other two teachers from Wenago and the teacher in Donbosco, revealed their weakness even though they reasoned there was insufficient time allotment for teaching chemistry including practical activities. In the Ethiopian secondary schools' laboratory schedules are not included in the time table of the normal teaching and learning process. Therefore, it is up to the teachers and the students to arrange laboratory schedules usually either in the other shift or on Saturdays and Sundays. This is not being considered as part of the proper load for the teachers and hence no teacher is encouraged to do so.

Table 2 Teachers responses to questions in the questionnaire

No	Question	Response	Wenago	Donbosco
1	Is there functional laboratory in your school?	Yes	-	√
		No	3	-
2	If you have nonfunctional laboratory in the school, what does it lack? You can choose more than one.	Running water	3	-
		Electricity	3	-
		Proper workbench	1	-
		Some of the basic apparatuses	3	-
		Some of the necessary chemicals	3	-
3	Is there any problem of getting chemicals for the experiments in grade 10 chemistry in your school laboratory?	Yes	3	√
		No	-	-
		I don't know	-	-
		I am not sure	-	-
4	Have you assessed your laboratory facilities (e.g. chemicals, apparatus, etc) with regard to the possibility of doing experiments in the grade 10 chemistry textbook?	Yes	-	√
		No	3	-
5	If your response for question number 4 is "Yes", what percent of the experiments could be done in the school laboratory?	91-100 %	-	-
		81-90 %	-	-
		61-80 %	-	-
		41-60 %	-	√
		30-40 %	-	-
		Below 30 %	-	-
6	If there is a functional laboratory, have you done experimental demonstration(s), in grade 10 chemistry for the students?	Yes	-	√
		No	3	-
7	If your response for question number 6 is "Yes", how many experiments have you done from the grade 10 chemistry textbook?	1-3 experiments	-	-
		4-6 experiments	-	√
		7-9 experiments	-	-
		More than 9 experiments	-	-
8	Can you do some experiments in the classroom for students in your school based on the procedure set in the grade 10 chemistry textbook?	Yes	1	-
		No	2	√
		I don't know	-	-
9	How do you rate the interest of students towards doing chemistry experiments?	Very high	-	√
		High	2	-
		Medium	-	-
		Low	-	-
		Very low	-	-
		It is difficult to rate	1	-
10	Which one, do you think, is right?	All of the experiments in the grade 10 chemistry textbook can only be done in the laboratory	2	-
		Many experiments can be done in the classroom from the grade 10 chemistry textbook	1	√
11	Have you ever heard about small-scale experimentation?	Yes	-	-
		No	-	√
		Yes I do but I am not clear about it	3	-
12	Are you ready to get training on small-scale experimentation so that you can do experiments, in small-scale?	Yes	3	√
		No	-	-
		I am not sure	-	-

Though it is difficult to accept the rating of students' interest as very high and high by the teachers in Wenago School as the students did not do any experiments, the teacher in Donbosco School having seen students do experiments testified it as very high. However, it is very difficult to accept this as the teachers rated them having not seen students do many experimental activities.

Absence of enough knowledge of small-scale experimentation was reasoned out by the teachers saying that they did not come across the concept of small-scale experimentation in their educational career. It is true that the teachers did not come across the concept of small-scale experimentation as it is not familiar in the Ethiopian secondary schools, colleges and universities, so that the chemistry teachers showed interest to get training on small-scale experimentation.

A Hands-on Training

Three chemistry teachers (from Wenago) and one chemistry teacher (from Donbosco) were given a three days training by the researchers in Dilla University. In the training, they conducted all the 16 experiments in the student's worksheets. In addition, they were briefed on the historical background, significance and advantages of small-scale experimentation.

The teachers did not believe that the apparatus in the MYLAB kit would enable them do experiments in secondary schools, when they actually saw them for the first time, because of the small size. However, as they started conducting the experiments they began smiling. On the second and third day they enjoyed this thoroughly and were pleasantly surprised by the good results they obtained in the experiments. Above all they showed a very promising progress of small-scale experimental skill.

Students' Evaluation

Data obtained from students' quizzes and learner's self-evaluations are analyzed hereunder.

(1) Students' Quiz Scores

Quizzes that contained multiple-choice, fill in the blank spaces, short answer and true-false items were administered, in order to evaluate the learning gained in the experimental groups and the result is presented as follows.

The average achievement difference observed (in the quiz scores) between the experimental and control group students in Wenago was 15.17% (Table 3) and in Donbosco it was 16 % (Table 4). If all of the experiments in the textbook were done throughout the academic year and by considering the scores of students as part of their total mark, differences greater than this could have been obtained. It is not difficult to imagine how much experimental skills were gained from doing the experiments. Besides observation of unexplainable chemical phenomena, during the course of experimentation, is the other important chemical knowledge gained through experimentation.

Table 3 Quiz scores and the difference of the average scores between experimental & control group students (Wenago)

Group	Score (%)	Average score (%)	Difference (%)	Average score (%)	Score (%)	Group
Experimental	83.2	650/11 = 59.09	59.09 - 43.92 = 15.17	527/12 = 43.92	63.4	Control
	78				62.4	
	74.9				61.4	
	70.7				57	
	69.7				54	
	65.5				53	
	59.3				51	
	52				45.8	
	50.9				39.5	
	45.8				39.5	
	35.4				37.4	
	-				36.4	

The above results support previous work in small-scale chemistry (Vermaak, 1997 [9]; Towse, 1998 [10]) and seem to be consistent with other research which shows that students' participation in practical activities leads not only to greater understanding but also to greater interest in the study of chemistry (Demircioğlu et al., 2005 [11])

Table 4 Quiz scores and the difference of the average scores between experimental & control group students (Donbosco)

Group	Score (%)	Average score (%)	Difference (%)	Average score (%)	Score (%)	Group
Experimental	97.4	819.8/10 = 82	82-66 = 16	658.6/10 = 66	78.5	Control
	96.6				73.9	
	89.9				71.4	
	87.4				68.9	
	82.3				64.3	
	80.6				64.3	
	77.3				63.4	
	75.6				61.3	
	73.9				58	
	58.8				54.6	

(2) Learners' Self-Evaluation

The learners' self-evaluation checklist was directly taken from the grade 10 student's worksheet, prepared in North West University, South Africa. The intention of the self-evaluation was to evaluate the feasibility and ease of using the apparatus in the MYLAB kit, the clarity of procedures and observations on the worksheet, and related aspects of experimental activities. On their responses students showed their agreement as it is presented hereunder.

66 % of students did not agree on the sufficiency of their background knowledge to answer the background knowledge questions in the worksheet (Table 5). Most (85.5%) students found it not difficult to know the experimental procedures in the student's worksheet. For some students the names of the apparatus and preparation of the setups became challenging and they were observed seeking for help in the first few experiments.

Most (85.2 %) of the students agreed that they could easily see the experimental observations that were indicated on the worksheet. It is a common practice for students to be unable to see experimental observations easily as they were not preparing themselves very well before conducting experiments.

Table 5 Students response for the learner's self-evaluation

Area of evaluation	Agree completely	Agree	Agree with reservations	Undecided	Don't agree	Definitely don't agree
My background knowledge was sufficient to answer the background knowledge questions	0%	0%	18.5%	15.5%	22%	44%
I had difficulty in knowing the experimental procedures	2.9%	1.4%	7.3%	2.9%	60.3%	25.2%
I could easily see the experimental observations	51.4%	33.8%	1.4%	4.4%	0%	9%
It was difficult to reach conclusions from the experimental results	1.4%	1.4%	4.4%	5.9%	54.4%	32.5%
I could easily relate the experimental result with my theoretical knowledge	55.9%	33.8%	5.9%	1.4%	0%	3%
I could not see the relationship between the experimental results and my everyday life	4.4%	10.3%	13.2%	11.8%	35.3%	25%

In the actual experimental work some students were observed repeating experiments to see the observations clearly.

Most (86.9 %) of the students agreed that it was not difficult to reach conclusions from the experimental results that were listed on the worksheet. Actually reaching conclusions from experimental results needs good understanding of the experimental activity and getting the anticipated result. However there were no evidences that could prove to us if their testimonies were genuine.

Almost 90 % of the students showed complete agreement on the ease of relating the experimental results with their theoretical knowledge. Normally experimental results were discussed both in their normal classroom discussions as well as in the pre laboratory talks. Henceforth, it will not be difficult for them to relate the experimental results with their theoretical knowledge.

Most (60.3 %) of the students agreed on seeing the relationship between the experimental results and their everyday lives. The decrease in the percentage of students that agreed on seeing the relationship between the experimental results and their everyday lives compared to the other agreements on the various aforementioned points seems genuine. This perhaps is partly due to inability to recognize the different chemical phenomena happening in their everyday lives. In addition to this most students do not realize the materials they are using in their daily lives were chemical substances or the results of a certain chemical process. In addition, they might not recognize most of the techniques they are using in their everyday lives as experimental techniques, perhaps thinking that chemical processes can only be seen either in chemical laboratories or in industries.

Table 6 Students' self-evaluation on the ease of following experimental procedures and becoming more familiar with handling apparatus

It is easier to follow experimental procedures and I am more familiar with handling apparatus than in previous experiments						
Experiment	Agree completely	Agree	Agree with reservations	Undecided	Don't agree	Definitely don't agree
4 & 5	46%	30.8%	0%	7.7%	15.5%	0%
6 & 7	71.4%	14.3%	0%	0%	14.3%	0%
8 & 9	36.4%	63.6%	0%	0%	0%	0%
10, 11 & 12	87.5%	12.5%	0%	0%	0%	0%
13, 14 & 16	88.9%	11.1%	0%	0%	0%	0%

In table 6 above, the ease of following experimental procedures and becoming more familiar with handling apparatus than in previous experiments is clearly seen. It is true that at every experimental session student got more exposure towards handling apparatus as they must touch, screw, unscrew, heat, tie, untie, manipulate, the different apparatus and prepare setup, etc. As they become more familiar with handling the apparatus, it becomes easier to follow experimental procedures.

Table 7 Lesson obtained from the experiment about nature and industry

This experiment taught me something about nature and the industry that I did not know before						
Experiment	Agree completely	Agree	Agree with reservations	Undecided	Don't agree	Definitely don't agree
1-3	46.2%	30.8%	7.7%	15.3%	0%	0%
4 & 5	61.5%	15.4%	7.7%	15.4%	0%	0%
6 & 7	57.2%	28.6%	7.1%	7.1%	0%	0%
8 & 9	45.5%	45.5%	9%	0%	0%	0%
10, 11 & 12	75%	25%	0%	0%	0%	0%
13, 14 & 16	66.7%	22.2%	11.1%	0%	0%	0%

The less percentage of students that showed agreement to the lesson they have got about nature and the industry that they did not know before (see Table 7) in experiments 1-5 is perhaps due to the laboratory preparation of the compounds (for example ethane, ethene and ethyne) and chemical reactions of some compounds (for example toluene and alcohols with active metals). In experiment 7 they have prepared soap and hence they could get a lesson about the way soap industries prepare soap.

Though 9% of students agree with reservation learning about nature in experiments 8 & 9, the percentage of agreed students increased very much, and no student was unable to decide unlike the previous experiments. In experiment 8 they were supposed to test for acidity and basicity of the oxides of substances like sulfur and magnesium. In experiment 9 they have done the effect of acids and bases on indicators using acids like HCl, H_2SO_4, HNO_3, the base NaOH and lemon juice. Therefore, it is quite obvious that these experiments could teach them about the nature of the substances they have used.

In experiments 10-16 (except 15), the percentage of students who learned about nature and industry showed slightly more than the rest of the experiments. The experiments were: the reactions of metals and acids (10 & 11), conductance of aqueous acid solutions (12), pH of solutions of common substances like lemon juice, vinegar solution, tonic water and tomato juice (13), which of course would teach them a lot about nature. The last two experiments are about conductivity of electrolytes like distilled water, table salt, sugar solutions, acids and bases (14) and constructing simple galvanic cells using tomato, lemon, and solutions of zinc and copper sulfate with the various metal electrodes (16), that could teach them about industrial processes through which electrolytes get prepared.

Table 8 Becoming up to date with the laboratory techniques and safety precautions

I am up to date with the laboratory techniques and the safety precautions necessary for this experiment						
Experiment	Agree completely	Agree	Agree with reservations	Undecided	Don't agree	Definitely don't agree
1-3	46.1%	53.9%	0%	0%	0%	0%
4 & 5	53.9%	46.1%	0%	0%	0%	0%
6 & 7	57.1%	28.6%	7.15%	0%	7.15%	0%
8 & 9	36.4%	63.6%	0%	0%	0%	0%
10, 11 & 12	87.5%	12.5%	0%	0%	0%	0%
13, 14 & 16	88.9%	11.1%	0%	0%	0%	0%

In all experiments students showed 100% agreement on becoming up to date with the laboratory techniques and the safety precautions necessary for the experiments, except in experiment 6 & 7 where 7.15% agreed with reservation and another 7.15% did not agree. This is perhaps because in experiment 6 they were supposed to prepare an ester (from acetic acid and ethanol) and detect the production of the ester by its aroma. However the excess acetic acid in the reaction mixture was an irritant to their nose, and they were observed complaining about that during checking out the product formation. There should have been some precautionary statement that makes students take care while detecting the product.

Second Round Discussion with Chemistry Teachers

A discussion was held after completing the experiments and the teachers revealed that it had been totally unexpected that they themselves and their students had actually got to do most of the experiments in the grade 10 chemistry textbook. They were so happy about this hands-on experimental training. All of them recommended the schools to acquire the MYLAB kits so that students in other grade levels could benefit too. They requested us to extend the project, and were happy with our response as we are not going to quit our project at grade 10 only. As University chemistry teachers we have a long term plan of activating the practical teaching of chemistry in the nearby secondary schools, as part of the community service rendered by the university.

Discussions with the School Principals

Discussions were made twice with the school principals. The first was simply a brief about the aim of the pilot project to which they responded very positively, allowing us to use all the school facilities for the project's implementation. They also became curious to see the result. In the second discussion, after the students had completed the experiments, principals were briefed about the knowledge gap between the control and experimental groups, the students' self-evaluation results (on the small-scale experiments) and the teachers' recommendations on getting the MYLAB kit. As a result, they have shown interest towards acquiring the MYLAB kit.

Interview with the School Principals

Wenago secondary school principal: According to the principal's testimony the chemistry teachers were last observed doing experiments five years ago. Several reasons were put forward to explain this lack of experimental activity. One was the introduction of experimental activities through plasma television into the school, which stopped the teachers from doing experiments. Another he explained, was the current condition of the laboratory where the water pipelines were damaged, and the electric lines were in place but disconnected from the main power. Some chemicals were available in the school, but whether these were adequate for grade 10 or other grade levels were unknown. The school budget was anyhow too small to cover the cost of laboratory facilities. The principal also explained that there is a school grant from funding sources other than the government, but this was not sufficient to fulfill the laboratory needs. He was glad to allow us to introduce the MYLAB kit to the school.

Donbosco secondary school principal: According to the principal there is a functional laboratory in the school. However, he was not sure if all of the experimental activities were done satisfactorily. His doubt was due to the fact that the chemistry class schedule in the normal school time was meant only for theoretical learning and experiments were supposed to be done on Saturdays, where both teachers and students were not obliged to come to school. According to his understanding the laboratory is well facilitated and there were no problems of chemicals, apparatus, workbench etc. The school is supported by volunteers from Italy and there is no serious budget problem. His willingness to allow us introduce the MYLAB kit to the school was very promising.

Assessment of the Schools' Laboratories

The laboratory in Donbosco School has the basic facilities like running water, electric power, apparatus, chemicals and one workbench (for demonstration purpose). It appears to be possible to do some of the experiments with the apparatus available. However, we are not sure if the chemicals allow them to do many experiments as most chemicals came from Italy and are labeled in Italian.

The "laboratory" in Wenago School did not possess a proper workbench, electric power, running water and there was no proper sewerage. There are very few chemicals, and those which are there might have deteriorated. Very few test tubes, beakers and some broken glassware were also there. Clearly it is quite impossible to use the room as a chemistry laboratory in the present condition. The room was never intended as a laboratory, and to upgrade it to a functional laboratory would be very costly.

CONCLUSION

The school laboratory assessment revealed the existence of a "laboratory" room with very few chemicals, equipments, apparatus, no electric power, no proper workbench and no running water in Wenago Secondary School and hence the students were unable to do experiments. On the other hand, in Donbosco Secondary School, there is a functional laboratory and the students had done some half of the experiments in grade 10 and some from the lower grades and in addition the teacher had conducted some demonstrations. However also in Donbosco, there appears to be a problem due to lack of some chemicals, apparatus and a laboratory technician and the separate laboratory scheduling in the school.

In both schools there was no clear understanding about small-scale experimentation up until this pilot was conducted. Giving hands-on training with the small-scale equipment, to the four chemistry teachers, was an opportunity that equipped them with the necessary skills. The preparation of student's worksheets in small-scale experimentation is also a great achievement that many secondary schools might use in the future. The introduction of the small-scale kit (MYLAB) into the schools was successfully done. Its achievement in motivating the chemistry teachers, the school principals and grade 10 students towards a meaningful teaching-learning process of chemistry was significant. Beyond the cases studied, the use of small-scale experimentation (such as MYLAB) can alleviate the deep-rooted problems of experimental activities in other Ethiopian Secondary Schools.

ACKNOWLEDGEMENT

We are very grateful for the financial support made by the NUFU joint project among Dilla University (Ethiopia), Norwegian University of Science and Technology (NTNU), and University of Zambia. We would like to give our appreciation for our partners in Norway, Professor Lise Kvittingen and Mr Kidane Fanta, for the unreserved support they have shown from the very inception of the project up until its completion. Many thanks to Marie du Toit and Corrie du Toit, North-West University, South Africa for enabling us obtain the MYLAB kits with its accessories.

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APPENDIX

This paper was originally prepared in 2011 in connection with a conference presentation. It was however never published. Nevertheless, others working in the same field in Ethiopia were aware of the draft paper and of the work it reported. Indeed the work was referred to by GM Tesfamarian in a paper presented at ACRICE-1, held in Addis Ababa in 2013 (5-7 December):

'Microscale chemistry (MSC) experimentation for Ethiopian secondary schools: Development and evaluation'

Subsequent to this an important paper, published in AJCE in 2014, expanded upon this and formally included the paper in the list of references (number 42):

G. Tesfamarian, A. Lykknes and L. Kvittingen (2014). Small-scale chemistry for a hands-on approach to chemistry practical work in secondary schools: Experiences from Ethiopia. AJCE 4(3), 48-94.

Around this time, and subsequently, there have been other papers in AJCE from Ethiopian researchers, which have added to the picture regarding practical science activities in Ethiopian schools:

Yitbarek, S (2012). Low-cost apparatus from locally-available materials for teaching and learning science. AJCE 2(1), 32-47.

Engida, T (2012). Development of low-cost educational materials for chemistry. AJCE 2(1), 48-59.

Maleta,T and Seid, M., (2016) Factors affecting implementation of practical activities in science education in some selected secondary and preparatory schools of Afar Region. AJCE 6(2), 123-142.

Shitaw, D., (2017) Practices and challenges of implementing locally-available equipment for teaching chemistry in primary schools of North Shawa zone in Amhara region. AJCE 7(1), 17-30.

It is interesting to note also that UNESCO, in cooperation with the Federal Ministry of Education, hosted a Microscience Training Workshop in Debre Zeit on 29-31 March, 2011. Teacher trainers from across the country (42), as well as curriculum developers participated. This was part of the official marking of the UN International Year of Chemistry. The workshop was conducted by JD Bradley, M Lycoudi and J Ovens and covered biology, chemistry and physics (electricity) experiments, using microscale kits designed by the RADMASTE Centre, University of the Witwatersrand, Johannesburg.

In summary, it is clear that around 2011 there was considerable activity in Ethiopia around practical work conducted on a small scale or on microscale, and that trial implementation took place not only then, but in subsequent years. Nevertheless, it is also evident that interest in locally-available or locally-produced low cost equipment continued, indicating the reality that, despite the interest several years ago, practical science activities are still the exception in Ethiopian schools. Publishing this 'lost' paper of Tegene and Hussein here, serves to indicate its primary importance in the history of the development of practical work in Ethiopian schools.

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