LOW-COST APPARATUS FROM LOCALLY AVAILABLE MATERIALS FOR TEACHING-LEARNING SCIENCE

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ABSTRACT

Learning science should start with hands on experiences that the child is familiar with and not with abstract definitions about what science is. Low cost apparatus from locally available materials believed to enrich the capacity to observe, explain and do real science in primary schools and increases the quality of learning. Hence the purposes of this action research were twofold: i) to design and produce appropriate low cost apparatus from locally available materials that can be used in teaching-learning science in primary schools, and ii) to compare cost and efficiency of the apparatus constructed using the low cost locally available materials with standard factory produced ones. Comparatively the low cost materials offered an alternative solution to do science in classrooms under difficult financial constraints. *[AJCE, 2(1), January 2012: Special Issue]*

INTRODUCTION

Chemistry is mainly an experimental, observational and laboratory oriented discipline, thus chemistry lessons must be developed to reflect this. Currently there is an urgent need everywhere in the world to have low-cost instruments and low-cost experiments for teaching chemistry. The situation is particularly serious in developing countries. As Tilahun, et al (1) indicated, in spite of various efforts, shortage of school laboratory apparatus continues to be a major problem which should be of serious future concern. There should be a gradual shift from importing expensive apparatus to a reliance on low cost apparatus designed and manufactures by utilizing locally available resources.

If we want our students not only to know "what scientists do?" but "how scientists do?" and do science for themselves, our students should be able to observe, measure, compare, classify, describe and evaluate. We are all born with the ability to be investigators; however, we have to learn how to do it. Hence if we base our teaching of science with locally available, it will make learning by doing accessible, even when the conditions for teaching are not conducive. It is believed that, using locally available materials, most primary school experimental lessons can be performed in a very short time, often with no or low financial input and without long sessions of preparation.

The essence of science education is an involvement and understanding of the process of science. Therefore, the effective use of the laboratory is a prerequisite in science education, as science is an experimental, observational and laboratory oriented discipline. The significance of laboratory activities can be understood in light of the following four broad roles (2). Laboratory activities can be a means of i) gaining basic laboratory skills, ii) developing observational skills, iii) explaining a particular concept, and iv) having best experience of what science is all about.

According to many scholars the advantage of using low cost materials can be summarized as (2, 3):

- use of local materials makes teachers and learners aware of the resources to be found in their environment and stimulates creativity to use them
- the experiments and models can be constructed in a very short time, with a few tools, with locally available materials even by unskilled persons as part of pre- and in-service teacher training
- the self-construction develops a sense of proud ownership and promotes a more frequent use
- repair and replacement of broken parts are possible locally without technical or administrative problems
- for the storage no special storage facility is needed; a lockable cupboard is enough. Security is no problem, because of the low material value
- for the implementation no special infrastructure is needed. The innovations go straight to the schools. What has been learned today in a training workshop can be applied tomorrow in the classroom

In spite of the many efforts to make science education effective and popular, there are many problems faced by planners and people responsible for the development of science education and among these problems the major once are related to practical activities. It has been recognized that teachers are reluctant in producing and using low cost materials for science laboratories, and lack of physical facilities due to financial constraints (1, 4).

MEANING OF LOW COST AND PURPOSE OF THE ACTION RESEARCH

Low cost in this action research refers to a systematic way of constructing a piece of apparatus or designing an experiment from locally available materials. It involves the following steps:

- Making a careful study of the conventional apparatus or experiment.
- Thinking of some low cost substitute that may be available in the locality.
- Designing the improvised apparatus or experiment.
- Putting the improvised apparatus or experiment to test. Making further improvements in the improvised apparatus keeping the test results in mind.
- Making use of the improvised apparatus in the laboratory for demonstration or practical work.

With this conception of low cost materials in mind, the purposes of the action research are i) to research, design and produce appropriate locally available materials in teaching-learning science in primary schools, and ii) to compare cost and efficiency of the apparatus constructed using the low cost local materials with standard factory produced apparatus.

RESEARCH QUESTIONS

The more concrete questions of the action research were:

1. What materials are available in the community to produce low-cost?
2. How can one design and produce so that others can simply repeat it?
3. How are the low-cost and manufactured apparatus compared in terms of cost and efficiency?

BASIC TOOLS FOR THE LOW COST APPARATUS PRODUCTION

The following basic tools were utilized to produce the low cost materials. The current price in Addis Ababa Ethiopia for the basic tools was 230 Birr (ETB). (Note that at the time the research was conducted, 16. 5ETB is equivalent to 1USD).

230 Birr (NB 16.5 Birr =1USD)

In this action research the following apparatus and setups were improvised: Filtration, Distillation, Titration, Gas preparation, Heating, Burning, gas preparation, Hoffan electrolysis, and common laboratory apparatus-Separatory funnel, beakers, stirrer, funnel, stand, test tube, test tube holder, test tube rack, Petri-dish, evaporating dish, models, wash bottle, spatula, measuring cylinder etc. To make this paper concise selected setups and apparatus will be presented.

Example 1: Filtration apparatus

1.1. Basic apparatus for filtration

Funnel

10 cent/ 34.61 Birr

Stand and Extension clamp

15 cent/ 161.73+ 40.25=201.98Birr

Beaker

10 cent/ 23.00 Birr

Stirrer

0.00 cent/ 2.00 Birr

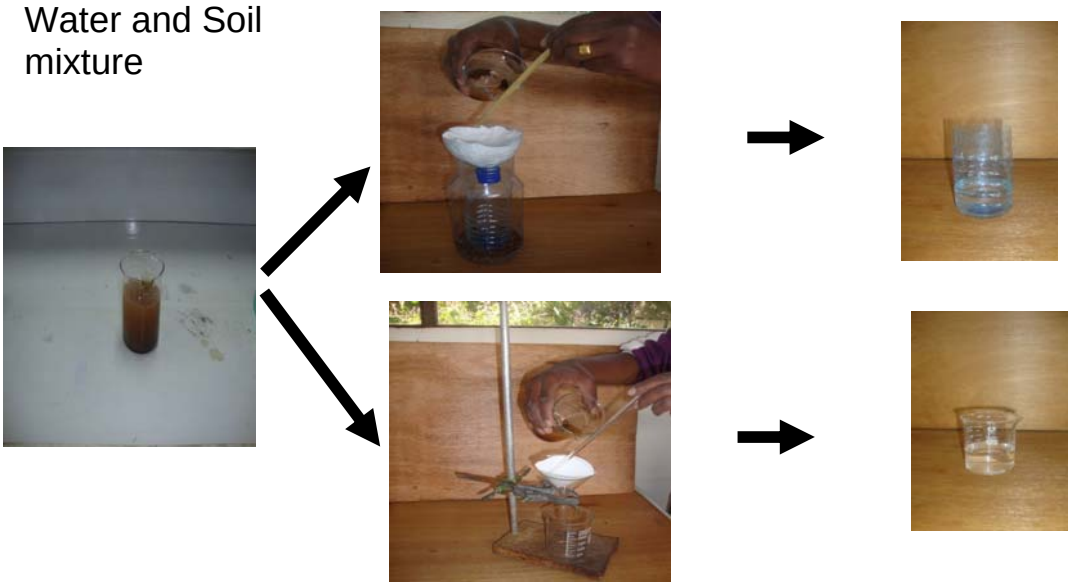
Filter paper

5Birr / 40.00 birr

1.2. Filtration apparatus cost comparison

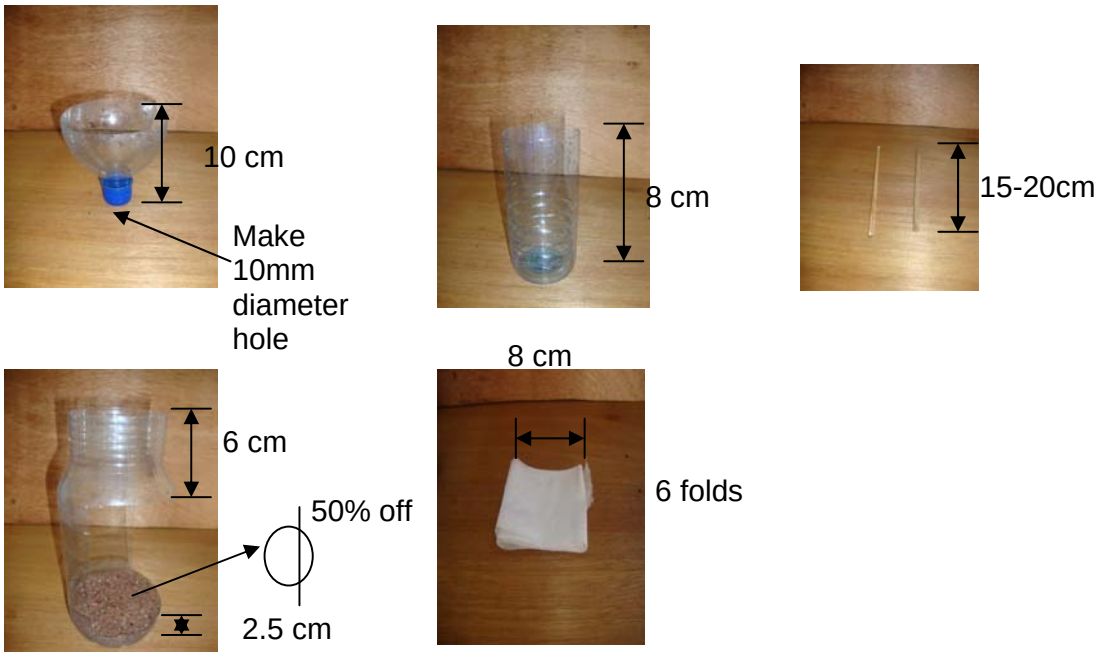
Apparatus	Unit Price	
	Improvised	**Manufactured**
Funnel	10 cents	34.61 Birr
Stand and Extension clamp	15 cents	201.98 Birr
Stirrer	0 cents	2.00 Birr
Beaker	10 cents	23.00 Birr
Filter paper	5 Birr	40.00 Birr
Total	**5.35 Birr**	**299.59Birr**

1.3. Comparison of Efficiency



Efficiency of low cost apparatus in regards to Time, separation, convenience, durability is about 98% compared to the factory manufactured one.

1.4. Filtration Construction Manual



Example 2: Separatory funnel

2.1 Low cost and imported

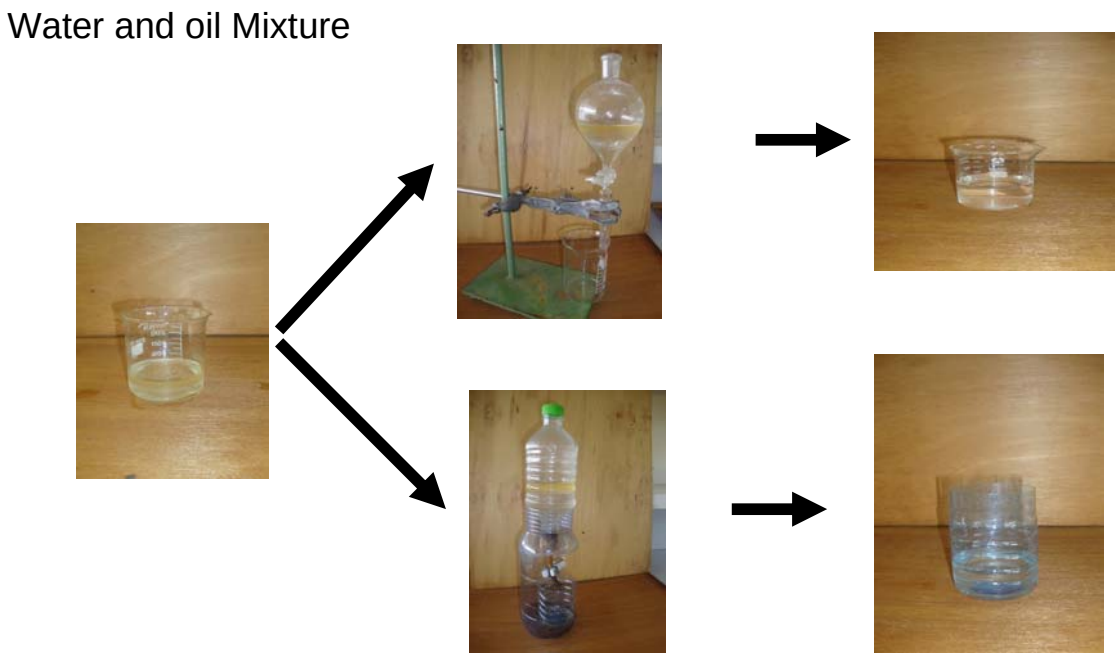
Stand and Extension Clamp
Beaker
Separatory funnel

2.2 Separatory funnel cost comparison

Apparatus	Unit Price	
	Improvised	Manufactured
Separatory Funnel	50 cents	85.00 Birr
Stand and Extension clamp	15 cents	201.98 Birr
Cork	50 cents	-
Beaker	10 cents	23.00 Birr
Pinch	3 Birr	-
Total	4.25 Birr	309.98Birr

N.B For 10 Separatory funnel setups the cost comparison was improvised 4.25ETBx10= 43ETB and manufactured 309.98ETBx10 =3,100ETB

2.3 Comparison of Efficiency of the Separatory funnels



Efficiency of low cost apparatus in regards to Time, separation, convenience, durability is about 99% compared to the factory manufactured one.

Example 3: Distillation Apparatus

3.1 Basic apparatus for distillation

Receiver

10 cents Birr / 20 Birr

Burner

7 Birr / 90 Birr

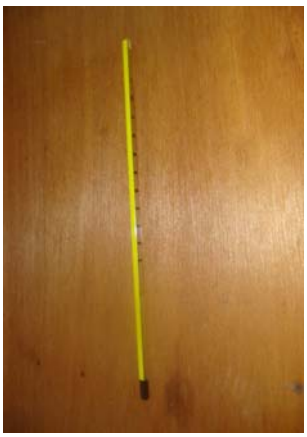
Condenser

3 Birr / 40 birr

Tripod

3 birr/ 60 Birr

Thermometer



19 Birr

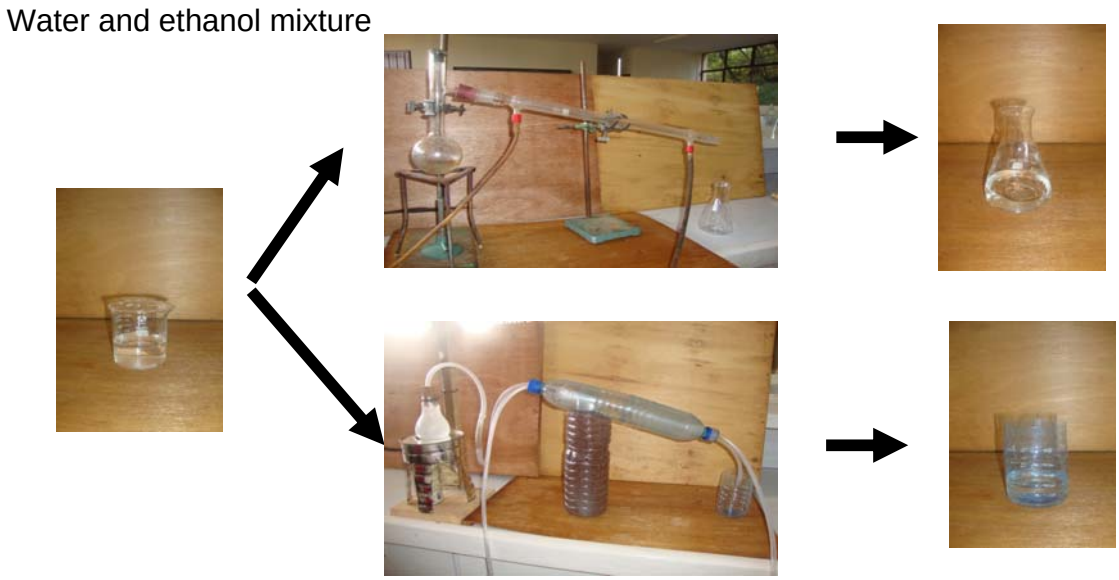
Trough

1 birr/ 95 Birr

3.2 Distillation cost comparison

Apparatus	Unit Price	
	Improvised	Manufactured
Distillation Flask	5.00 Birr	75.00
2 X Stand and Extension clamp	15 cents	201.98 Birr
Condenser	3.00 Birr	40.00 Birr
Receiver	10 cents	20.00 Birr
Burner	7.00 Birr	90 Birr
Tripod	3.00 Birr	60.00 Birr
Plastic tubing	10.00 Birr	10.00 Birr
Thermometer	19.00 Birr	19.00 Birr
Total	47.25 Birr	515.98 Birr

3.3 Efficiency of the distillation apparatus



Efficiency of low cost apparatus in regards to Time, separation, convenience, durability is about 95% compared to the factory manufactured one.

Optional distillation setup (comparative efficiency)

Example 4: Basic (Common Apparatus)

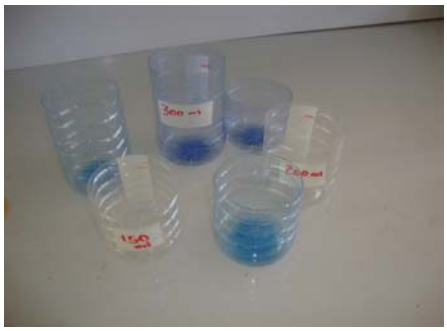
4.1 Measuring cylinder

8-11 Birr

25 cents

4.2 Beakers

35-38 Birr



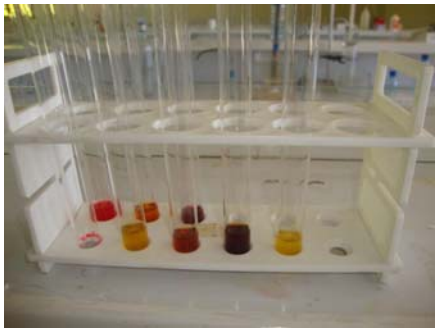
0.25 cents

4.3 Test tube holder and test tube

2 Birr

0.5 Birr

4.4 Test tube rack



Rack 22 Birr

Rack 50 cents

4.5 Washing bottles

20-35 birr

2 Birr

SUMMARY

1. Cost Comparison of All Setups Improvised and Manufactured

Apparatus	Unit Price	
	Low Cost	Manufactured
Filtration	5.35 Birr	299.59Birr
Separatory funnel	4.25 Birr	309.98Birr
Distillation	47.25 Birr	515.98 Birr
Titration	6.35 Birr	280. Birr
Gas preparation	4.50 Birr	214.00 Birr
Heating	5.00 Birr	127.00 Birr
Burning	4.00 Birr	150.00 Birr
Displacement of O2	12.00 Birr	400.00 Birr
Hoffman	8.00 Birr	780.00 Birr
Common Apparatus	28.35 Birr	1,599-1,672 Birr
Total (app.)	125.00 Birr	4700.00 Birr

2. Comparison of Efficiency of Low Cost Materials with the Manufactured Ones

Apparatus	% Efficiency Low cost
Filtration	90
Separatory funnel	99
Distillation	95
Titration	50
Gas preparation	80
Heating	60
Burning	100
Displacement of O_2	100
Hoffman	60
Common Apparatus	100
Average	83%

CONCLUSIONS

The following conclusions were drawn from the action research:

- Design and production is relatively easy
- Our local community is rich in materials
- 1 manufactured = 40 Improvised (Low Cost)
- Low-cost apparatus are really efficient and low cost or no cost

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