An Assessment of the Impact of Improvised versus Conventional Laboratory Equipment on Students' Performance in Thermal Expansion

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Abstract

Science education in Rwandan schools still faces a number of challenges including the lack or shortage of equipment available for science experiments. This paper describes research conducted to assess the impact of using improvised versus conventional laboratory equipment in experiments. Eighty-five lower secondary school students were assessed using a semi-experimental post-test design on thermal expansion of bodies. Data analysis using a t-test produced a t-Stat of 2.74 over a t-Critical of 1.98 indicating a statistical significance between the two experimental groups in favor of the group using improvised equipment. As a result, it is recommended that improvised equipment be used in those instances in which there is a lack or shortage of conventional equipment since students' achievement was similar regardless of the type of equipment used.

Keywords: improvised experiments; conventional equipment; thermal expansion

Introduction

According to Piaget (1970) in Onwioduokit (2013), children learn best through doing and actively exploring their environment. By implication, therefore, science should be taught in such a way that students themselves carry out useful activities. Thermal expansion of bodies is among demonstrative phenomenon in heat and thermodynamics that Physics learners should enjoy. Most science teachers perceive that laboratory activities are essential in teaching science as they stimulate students' interest and develop their scientific skills (Dillon, 2008), and hands-on activities are the most successful strategy for effective science teaching and learning (Sandifer & Haines, 2009). Experiments offer students opportunities to think about scientific concepts and to discuss and solve problems (Amimbola, 2006; Woodley, 2009). Experimental learning may provide a strong base for students to develop long-term memory as they have the opportunity to learn by doing (Tobin, 2008). In addition, a deep understanding of science concepts comes with practical instruction (Olufunke, 2012) because practical activities engage students through data collection, interpretation and making inferences (Mortimer & Scott, 2003). Consequently, the teaching of science which does not incorporate practical work is out of step with the ideals of science teaching (Omolo, 2009) because students may not be able to connect theoretical scientific concepts with the real world they live in (Suleiman, 2013).

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Through science experiments, students will be able to reflect on natural events and carry out activities that will enhance their cognitive skills (Eren et al., 2015). Experimental work is an active learning method requiring students to observe or manipulate real objects and materials, all of which have a distinctive and central role in the development of students' understanding of scientific concepts, improving cognitive skills as well as developing positive attitudes to the discipline (Tarhan & Sesen, 2010). This is why it is recommended that science teaching and learning should be focused on the use of scientific activities to investigate real-life phenomena (Hofstein & Mamlok-Naaman, 2007; Tobin, 2008). However, as Angus and Keith (1992) ask; "Do we obtain a good quality education when teachers make a few demonstrations using expensive or sophisticated equipment?". The scarcity and cost of imported materials for teaching science have remained a major challenge to teaching sciences in developing/ non-Western countries (Nkechi & DomNwachukwu, 2006). Hence, improvisation in science education is of paramount importance in developing countries. According to Nkechi and DomNwachukwu (2006), such improvisation involves the adaptation or modification of original materials and equipment so that they can perform new functions in the laboratory.

Physics is a key subject in the secondary school curriculum because it enables learners to apply the principles, acquired knowledge and skills to construct appropriate scientific devices from available resources (Wambugu, Changeiywo & Ndiritu, 2013; Daniela, Popescu, Ioan, & Andrei, 2015). However, researchers have found that students find it difficult to grasp abstract concepts such as heat, light, electricity, magnetism, etc. (Welzel, 1998). Teaching thermal expansion as relationship of temperature with the tendency of shape, area, and cubic change of matter has faced challenges in enhancing students' interest during experimentation due to the lack of effective and easy materials. Therefore, the aim of this study was to compare the performance of students who were taught thermal expansion unit using improvised (teacher-made) or conventional (standardized) equipment. The findings of this study are expected to benefit science teachers in all Rwandan secondary schools in assessing the potential of improvising local materials to let students grasp and enhance their understanding of concepts related to thermal expansion specifically and heat and thermodynamics in general.

Methodology

The research aimed to measure the effectiveness of improvised versus conventional laboratory equipment on student learning and was conducted with the participation of 85 Grade 7 students from two classes (made up of 44 students and 41 students respectively) randomly selected from a secondary school in the eastern province of Rwanda in the 2015 academic year. This study was of a semi-experimental post-test comparative design conducted within the scope of a thermal expansion topic, with experiments carried out using improvised equipment in the case of the first group and conventional equipment with the second group. In the implementation stage of the research, each group conducted 3 experiments over a 3 lesson period in one week. A semi-open-ended experiment method (Aydoğdu et al., 2013), where the open parts of the experiment are expected to be completed by the students was used. In addition to experiment worksheets given to both groups, students in one group were given improvised materials such as a wooden plate, 2 nails and a coin, water, aluminum can and alcohol, straw, pet bottles and balloons, while the conventional equipment group was given traditional laboratory materials such as a bimetal strip, a metal ring with a ball, a glass beaker, a jar of water and a Bunsen burner. After performing these experiments related to thermal expansion (linear, area, and volume), an open-ended test was completed by both groups.

Results and Discussion

In terms of data analysis, the t-test was used for independent samples in test scores obtained from the improvised and conventional equipment groups. The test was marked out of 5 as the total score from all questions asked (1 score for each test area). Table 1 shows all scoring procedures and descriptive findings.

Table 1 Scoring area and Descriptive statistics

		Improvised Lab			Conventional Lab		
	Area of test questions	Frequ-ency	Mean score	SD	Frequency	Mean score	SD
1	Properties of "Cooling wood"	11	0.25	0.43	15	0.37	0.48
2	Properties of "heated Aluminium can"	34	0.77	0.42	25	0.61	0.49
3	Experiment on "Linear thermal expansion"	31	0.7	0.46	21	0.51	0.5
4	Experiment on "Areal thermal expansion"	18	0.41	0.49	18	0.44	0.5
5	Experiment on "Volume thermal expansion"	27	0.61	0.49	6	0.15	0.35
	Total		2.75	1.19		2.07	1.05

Figure 1 shows the means of students' scores with the improvised equipment group generating a mean of 2.75 while the conventional equipment group had a mean of 2.07.

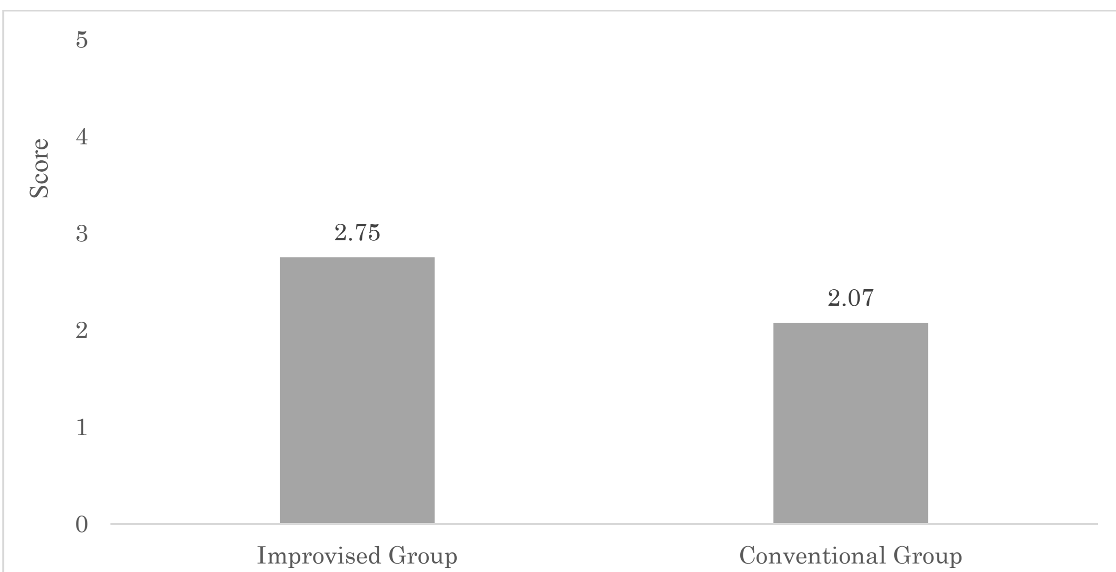

Figure 1 Mean score of all groups

Thus, the t-test for independent samples of test scores from the improvised and conventional experiments produced a t-statistic of 2.74 when a t-critical one tail of 1.66 at 83 degrees of freedom was considered (See Table 2). Therefore, there was a statistical significance between these groups in favor of the improvised equipment group.

Table 2 T-test of two-sample assuming equal variances of improvised and conventional equipment groups

	Improvised	*Conventional*
Mean	2.75	2.07
Variance	1.447674419	1.119512195
Observations	44	41
Pooled Variance	1.289523949	
Hypothesized Mean Difference	0	
df	83	
t Stat	2.745827361	
P(T<=t) one-tail	0.00369937	
t Critical one-tail	1.663420175	
P(T<=t) two-tail	0.00739874	
t Critical two-tail	1.98895978	

There seems little doubt that the materials of greatest value are those to be found in the immediate environment because these are within everyone's experience and they are less expensive than traditional science laboratory equipment (Angus & Keith, 1992). The results from the present study confirm those of by Ekpo and Ushie (2010) who found improvisation of materials to be generally better-suited to the climatic conditions of the local environment since learners will interact with the materials around them every day, thereby promoting local sourcing of experimental materials and encouraging the creativity of teachers and learners. Like in the present study, the study conducted by Owolabi and Oginni (2012) also showed that there was a significant difference in the performance of students who used improvised and non-improvised resources. The study of Udosen and Ekukinam (2013) using a t-test statistical analysis also revealed that pupils benefited equally from the standardized science and improvised equipment. In addition, they highlighted the efficiency of low-cost apparatus in regards to time, separation, convenience, and durability which was about 98% compared to factory manufactured ones (Sileshi, 2012). In the present study, the improvised materials like plastic bottle, straw and balloon can demonstrate volume thermal expansion than conventional materials like a bimetal strip could do. For instance, 27 out of 44 students in improvised lab alongside 6 out of 41 students in conventional lab performed test question related to volume thermal expansion (see Table 1).

Conclusion and Policy Implication

A statistical significance between the use of improvised and conventional equipment occurred in favor of the improvised group. It is, however, important to note that complicated or precision instruments may not be improvised as easily due to their complexity and specificity (Udosen & Ekukinam, 2013). As a recommendation, because of the generally greater accuracy of conventional equipment, where possible, improvised experiments should also be carried out alongside conventional experiments using ready-made equipment. Since the improvised materials showed potential in learning achievement as well as being low cost, educational institutions should find ways of creating and sharing readily available resources that can be used to teach specific subjects such as Physics and Science, in general. In addition, pre- and in-service teachers should be actively encouraged and trained to make use of materials available in their immediate environment.

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