The Impact of Virtual Experimental Techniques on the Performance of 1st Year Heavy Equipment Repair Technicians Students at Northern Technical College

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Abstract
There is no doubt that the performance of students in Physics in Zambian colleges had fallen drastically. This was mostly attributed to misunderstanding of specialized terminology in the subject. This terminology often assigned new meanings to everyday terms used to describe physical models and phenomena. The aim of this research was to investigate the impact of integrating virtual experiment in teaching Friction on learners' conceptual understanding. Tests of the theoretical framework were presented in the context of "velocity ratio" and "mechanical advantage" in Friction. The research was conducted in two classes namely the HER A and HER B. The participants were selected from four classes namely the HER A, HER B, HER C and HER Dclasses at NORTEC. 120 participants were selected from two classes. Simple random sampling procedure using a drawing method was employed. One of the classes was used as an experimental group, while the other one was as the control group. The use of already existing classes was so as not to interfere with the program by learners changing classes. The research was carried out systematically with the use of a teaching method in which the pupils were taught by virtual experiments. The research design used was a pre-test post-testquasi experimental research design. Pretest and posttest were administered, summative evaluation were carried out with virtual experiments on the topic (Friction). The scores collected from the evaluation were analyzed with the use of T-test analysis to show the mean scores of the students respectively. The findings showed that there was a significant difference between the students taught with virtual experiments and those taught without virtual experiments.

1. Introduction

According to Hatherly (2015), a virtual laboratory is one where the student interacts with an experiment or activity which is intrinsically remote from the student or which has no immediate physical reality. The concept on the virtual experiments is to bring as close a connection to reality of physical experiments as possible, to as many students as possible.

Due to the rapid changes in science and technology of today's world, new methods and techniques are used in science teaching. One of the most important of these is the virtual experimental technique. This technique appeals to multiple senses and makes learning maintained to a greater extent over time.

Virtual experiment technique is a simulation based technique performed with virtual experiment tools in computer environment, Liu, Lin, & Kinshuk (2010). This technique is performed by students in computer environment with virtual tools, virtual people, virtual materials, and virtual liquids, Lefkos, Psillos, & Hatzikraniotis (2005)

With simulation techniques which can easily be applied to the computer, the required information can be provided. The real experiments may be long lasting, expensive, dangerous and impossible to perform. This technique allows performing such experiments in a fast, cheap, and safe way, Bernadatte (1983). Some difficult concepts become more concrete in students' mind with laboratory activities. As a result of this concrete experience, students can learn the relations between principles and concepts of science more permanently.

The theory of experiential learning stems from the constructivist of thought. John Dewey first wrote about the benefits of experiential education in 1938, explaining that there was an intimate and necessary relation between the processes of actual experience and education, Dewey (1938/1997). Experiential learning theory propagates learning through experience and by experience. According to this theory, learning is understood as an interactive process whereby knowledge is created through the transformation of experiences, Kolb (1984).

According to Kinder (1973), people remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 80% of what they see, hear and say, 90% of what they see, hear, touch and say. We live in an era characterized by the rapid development of technology. Computer science has invaded the educational process and is providing us with many opportunities to exploit. An additional challenge faced by STEM educators has been the integration of Inquiry Based Science Learning (IBSL) in teaching. While the use ICT has already penetrated in Inquiry Based Teaching, we have yet to create and implement STEM lesson plans that promote the development of methodological skills and competencies, investigation through experimentation, teamwork and communication among students through collaborative activities.

In recent years, Inquiry-Based Science Education (IBSE) has proved its efficacy in education by expanding on "traditional" lessons and motivating students to actively participate in science. IBSE methods and digital technologies support necessary educational innovations and can be the catalyst for change in educational patterns. Virtual laboratories are an essential digital tool. In fact, many European schools are equipped with computer classes, tablets and high-speed internet connection while using a huge variety of web-based learning applications, simulations and visualizations.

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Statement of the Problem

The poor performance of students in Engineering Science at Northern Technical College has been a thing of concern to Engineering Science Educators, the administration and Parents Guardians and Sponsors. According to Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA), examination results reports analysis for 2014, 2015, 2016, and 2017 for 1st year Heavy Equipment Repair Students at NORTEC were 47%, 42%, 65% & 27% respectively.

The perception/myth that science in general is a difficult subject to understand has also brought about many challenges especially for first year students. Engineering Science involves mathematical calculations as well as many other foreign languages such as; Greek and Latin. The use of quantity symbols such as Alpha (α) and Omega (Ω) has also contributed to the perception that Physics is a difficult subject to understand.

Many colleges in Zambia lack the laboratories and necessary equipment required to effectively teach students in Physics. Therefore, many first year students at higher institutions of learning such as Northern Technical College have never even seen an experiment (i.e. physical or virtual) being performed. According to Ausbel (1962), in Rote Learning, there is often little emotional commitment other than to recall the information and the extrinsic motivation that comes with getting the right answer. Gender participation in Physics and other sciences at NORTEC has been reduced due to the lack of effective tools and laboratories required to facilitate teaching and learning. For example, January 2018, 1st year students in Heavy Equipment Repair only comprises of 2 female students out of a total enrolment of 120 students.

Purpose of the Study

This study aims to analyze the impact of virtual experimental techniques as an educational tool in supporting students to increase their active learning process and understanding of Friction. The main purpose of the study is to identify the benefits and challenges associated with using virtual experimental techniques and factors to consider when planning the development and implementation of virtual laboratories at Northern Technical College.

This study aims to analyse the impact of virtual experimental techniques as a tool in supporting students to increase their active learning of friction as well as an effective teaching aid for lecturers.

Significance of the Study

This study was designed to contribute to the body of knowledge. It was hoped that the information generated in this study would contribute to current literature on whether the using virtual experiments enhanced students' comprehension of Physics concepts. The study was important because the findings would provide very important information that would be useful to administrators, lecturers, pupils, the Ministry of General education and the government at large. The findings would further help policy makers and other stakeholders at NORTEC to strengthen strategies and policies of improving the academic performance of learners in Physics.

This study may contribute to the students' improved performance in friction. The results of the study will reveal improved teaching strategies that could be used by Lecturers and Science Educators so that they become more efficient and effective as they deliver learning instructions in this 21st Century.

In addition to some to the researches that has been conducted in Zambia over the concept of virtual experimental techniques, this study will be used by the stakeholders to effect curriculum change and design to address the students' difficulties in learning Friction and related topics in Physics.

2. Literature Review

Chapter two reviews related literature of what other scholars have established on the impact of integrating a local language in teaching Friction on learners' conceptual understanding.

Physics is the science of experimental evidence, criticism, and rational discussion where knowledge and understanding of its concepts depends on the perception of the physical phenomena. Among many researchers in Physics education, Halloun and Hestenes (1985) and McDermott (2001) have shown the ineffectiveness of traditional instructional methods, and shed the light on the lack of understanding science content and processes when students were subjected to conventional teaching of lecture and demonstrations. Resorting to laboratory experiments is one of the main efficient means to make the comprehension of difficult theories simpler and clearer (McDermott, 2001).Meaningful learning, can be achieved when laboratory activities become an integral part of the science curriculum (NSTA, 2007). According to Onyesolu (2009) learning science has been restrained by the deficiency or inadequacy of laboratory equipment in schools. From this standpoint, there is a need for a new unconventional alternative laboratory environment where students can conduct the different required experiments at any time and in safe conditions. One of the solutions that may help in overcoming these obstacles can be the use of virtual laboratories.

According to Halloun (1996) resorting to progressively sophisticated software endorses a constructivist approach to learning. Pedagogical principles of inquiry-based learning, exploration, and genuine activities in science support the use of technology in an attempt to provide basic instruction mainly due to the increasing importance of enhancing students' motivation and engagement in science instruction. Virtual laboratories offer students the opportunity to achieve the learning objectives, while overcoming the aforementioned constraints. Virtual laboratories have therefore arisen in schools and universities as being powerful efficient tools that may offer wide-range alternatives as learning environments that attract students' interests and may be a great incentive to them (Onyesolu, 2009). In Lebanon, the Center for Educational Research and Development (CERD), established and categorized competencies that must be developed in science into four domains: Using acquired knowledge, practicing scientific reasoning, mastering experimental techniques, and mastering communication techniques (CERD, 1995). The experimental techniques depend extremely on laboratory work and experiments that unfortunately are not used in most Lebanese schools, particularly the public ones, due to a number of barriers (Zgheib, 2013). As a physics teacher for secondary classes in Lebanon since 2008, the first researcher has tried to resort to laboratory experiments in her teaching approach. However, she was able to realize only few experiments due to the lack of laboratory equipment on one side and the inexpertness of students on the other. Some of the main problems she has encountered during her experience in the secondary teaching were: The insufficiency or absence of laboratory facilities; the time factor in planning and performing experiments; and the inability to keep tracking of students' performance during the activities. Based on this approach, and in order to solve the problems faced, experiments were conducted by replacing the real lab with a virtual laboratory.

According to Aldrich (2005) virtual labs help students conduct experiments and explore phenomena that cannot be conducted in traditional laboratory surroundings, either because it is not feasible or because of the unavailability of essential laboratory equipment. Virtual Laboratories provide simulated versions of traditional laboratories referring to a learner-cantered approach in which the learner is provided with objects that are virtual representations of real objects used in traditional laboratories. Virtual laboratories may contribute to teaching and learning processes by giving students the opportunity to learn by doing, providing them with intriguing and enjoyable activities urging them to discover, and guaranteeing an active classroom interaction by means of discussions and debates (Lkhagva, Ulambayar, &Enkhtsetseg, 2012).

The use of virtual laboratories can offer students the opportunity to investigate situations that cannot be tested in real time by speeding up or slowing down time (Aldrich, 2005). They are also beneficial to study advanced concepts such as relativity and experimentation that would not be studied or realized in traditional laboratory settings (Aldrich, 2005, Reese, 2013, Scheckler, 2003). Virtual laboratories offer a visual context for numerous abstract concepts and provide notable visualization and graphical analysis abilities (Wieman&Perkins, 2005). Virtual lab instruments are used to save space and time. They can be more easily assembled and more properly used than real laboratory equipment, and therefore are more time efficient than traditional hands-on laboratories (Reese, 2013). They may resolve the problem of crowded groups and help the non-visual or auditory learners to interact with their learning environment (Mestre, 2006). In addition, they are cost effective since up-to-date lab equipment and supplies, in addition to their shortage, can have high operational cost in traditional laboratories (Ma &Nickerson, 2006). Dangerous experiments can be safely conducted through virtual laboratories (Scheckler, 2003).Despite all advantages, some researchers highlighted certain disadvantages such the lack of students' hands-on approach, the lack of lab partner which may facilitate peer-learning (Scheckler, 2003).Review of Research Comparing Virtual and Traditional Laboratories. The latest modifications and progresses in educational delivery, especially in the field of technology have raised many questions concerning the effectiveness of the virtual laboratory as an instructional tool. One of the studies done in Lebanon in this domain is the one done by Zoubeir (2000). The researcher explored the impact of a constructivist approach through the use of computer projected simulations and interactive engagement approaches. The analysis of the data collected showed an improvement in the conceptual understanding of Newtonian mechanics exclusively in the experimental group that taught with the use of projected simulations. However, the research did not find a statistically significant difference between the two groups neither in students' views about physics, nor in their performances in the exams (Zoubeir, 2000).Ma and Nickerson (2006) accomplished a literature review, of 20 articles, regarding comparative usefulness and perceptions of simulated, remote, as well as hands-on laboratories. The findings revealed that educators could not consent on the efficiency of each lab type in comparison to one another, claiming that each study had different educational outcomes and instruments/methods to measure the effectiveness. Finkelstein et al. (2006) compared the usage of PhET simulations with the usage of traditional educational resources in all the settings of teaching introductory college physics including laboratory, lecture, recitation and informal settings. They demonstrated the utility of PhET simulations in a wide array of environments in teaching undergraduate physics, and concluded that under favourable conditions those simulations could be as profitable and even more, than the traditional educational tools including textbooks, live demonstrations, and even real equipment. To document the efficiency of the use of a computer simulation, specifically the (CCK) developed by the PhET, Keller, Finkelstein, Perkins, and Pollock(2007) made a comparison between students viewing CCK and those viewing a traditional demonstration during Peer Instruction. Results showed that students viewing CCK presented a larger relative gain in conceptual understanding measures in comparison with traditional demonstrations. In a study conducted by Tüysüz (2010) on 341 chemistry students from the high school level, the influence of virtual experiments on the students' achievements and attitudes were investigated. Results showed that students' attitudes towards chemistry have varied according to teaching methods used in the study, and that virtual laboratory practice had a positive influence on students' achievements and their attitudes toward chemistry when compared to traditional instruction method.

Tüysüz (2010) argued that using computer in science teaching is appropriate and convenient, particularly when the content is well employed. Similarly, Bozkurt and Ilik, carried out a research on 152 physics students at the University level aiming to assess the influence of the use of interactive computer simulations in teaching on students' achievements and beliefs about physics. For this aim, lessons were taught according to traditional instruction methods for the control group and resorting to computer simulations prepared by PhET for the experimental group. Students were subjected to a pre and post success test, as well as a 5-point Likert scale test (CLASS) used to identify their beliefs on physics and learning physics. The results showed enhancements in the students' beliefs before and after the treatment. In addition, it was noticed that groups who studied by means of computer simulations had better achievements than those who learned through traditional methods (Bozkurt&Ilik, 2010). Shegog et al. (2012) conducted a randomized clinical control design study on a sample of 44 students from two high schools to evaluate the skills and knowledge about the molecular labs processes as well as students' attitudes towards science and computers by using HEADS UP Virtual Molecular Biology Lab as an instructional tool. The Virtual Lab was found to lead to a significant development in students' knowledge with time; however, the researcher did not notice any significant differences in science attitude scores. Similar results were found by Tsihouridiset al. (2014) who conducted a study in which students were able to use both real and virtual lab according to their educational needs. The results showed that the use of the virtual lab, as a mobile School-Lab, during teaching considerably enhanced the students' conceptual understanding of certain physics concepts. Recently, Brinson (2015) presented a review 56 articles published in and after 2005 that emphasized on comparing learning achievements by using traditional and non-traditional lab participants as experimental groups. Results proposed that most of the reviewed studies (n=50, 89%) have shown that student learning outcomes were equal or higher in ―Non-traditional Lab‖ in comparison with ―Traditional Lab‖ concerning all learning outcome types (knowledge and understanding, practical skills, inquiry skills, perception, analytical skills, as well as social and scientific communication). In contrast, Quinn, King, Roberts, Carey, and Mousley (2009) found that students in some conditions could reach a better understanding of topics after hands-on laboratories, when compared to virtual labs. They concluded that it was due to the fast distraction of students while working with simulations, whereas in hands-on laboratories, students were able to maintain focus throughout their involvement. Similarly, specialized establishments for science education, like the National Science Lecturers Association, emphasized the roles of hands-on activities in improving students' interest and acquisition of science skills (NSTA, 2007). Tsihouridis, Vavougios, and Ioannidis (2013) compared the effectiveness of virtual lab and real school-labs in teaching electric circuits at Upper High-School. The analysis of the collected data showed that there was no significant difference between the two groups in their conceptual understanding of the basic concepts of electric circuits. However, some individual non-significant differences in favour of the real-lab group were observed in the 3 out of 12 teaching objectives. These results led to the conclusion that the two teaching approaches used would decisively help students to develop an investigative attitude relating to everything scientific, their cooperative skills, and their ability to express important queries with clarity and precision. The unison of the two types of lab was tested by Zacharia (2007) who examined the worth of joining real and virtual lab experiments concerning the modification in students' conceptual understanding of electric circuits' concepts; the researcher discovered that this arrangement improved students' conceptual understanding more than the use of real lab experiments solely. Supporting the same standpoint, the American Chemical Society (ACS) stated in 2011 that computer simulations mimicking laboratory processes are likely to be valuable supplements to student hands-on activities, but could not substitute them (ACS, 2011). Tsihouridis et al. (2015) investigated the effect of the use of real and virtual lab in changing order in the teaching of the electric circuit concepts for third year high school learners. The results revealed that the order of the real and the virtual lab in the teaching process affected the understanding of the scientific concepts related to electric circuits. Tsihouridis, Vavougios, and Ioannidis (2016) found that the cyclical process of virtual and real lab, without seeming to be a straight repetition, maintained learners' interest by enhancing their critical thinking and improving the learning process.

The review of literature lacks important studies on Arabic students in general and on Lebanese ones in particular, except those done by Zgheib (2013) and Zoubeir (2000). Lebanese students rarely used the virtual lab and the new technology in their learning process due to many barriers (Zgheib, 2013). This study was conducted on Lebanese secondary school students to investigate the effect of virtual physics labs on Lebanese learners.

2. THEORETICAL AND CONCEPTUAL FRAMEWORK

The cognitive constructivist approach by Piaget emphasizes that students construct knowledge by transforming, organizing and re-organizing previous knowledge and information, (Santrock, 2011). Vygotsky's social constructivist approach on the other hand emphasizes that students construct knowledge through social interactions with others. The content of this knowledge is influenced by the culture in which the student lives, which includes language, beliefs, and skills. While Piaget emphasizes that lecturers should provide support for students to explore and develop understanding, Vygotsky emphasizes that lecturers should create many opportunities for students to learn by co-constructing knowledge along with the teacher and with peers. In both models, a teacher is expected to serve as facilitator and guide rather than director and moulder of children's learning.

According to Felix (2002), the constructivist assumption is that learners are active constructors of knowledge who bring their own needs, strategies and styles to learning, and that skills and knowledge are best acquired within realistic contexts and authentic settings, where they are engaged in experiential learning tasks. The constructivist theory of learning considers individuals as active agents who engage in the construction of their knowledge by integrating new information into their schema, and by associating and representing it in a meaningful way (Jee, 2010). This approach emphasizes authentic and challenging projects that associate lecturers, students and experts in the learning community, more closely related to the world outside learning institutions. In an authentic environment, learners assume responsibilities for their own learning. They have to develop meta-cognitive abilities to monitor and direct their own learning and performance. Jee (2010) further argues that when people work collaboratively in an authentic activity, they bring their own framework and perspectives to see a problem from different angles, hence being able to negotiate and generate meanings and solutions through shared understanding.

Clark and Mayer's (2003) research clearly demonstrates that under some conditions learners learn better when they are able to hold corresponding visual and verbal representations in their working memory at the same time. They investigate the 'dual coding theory', in which the representation and processing of information concerning verbal and nonverbal materials are handled cognitively by separate subsystems (Clark &Paivio, 1991; Paivio, 1986). In particular, it is shown that phonological and visuo-spatial information is stored in short-term memory by different processes with different resources. Hence, a word encoded in a verbal way will be better recalled if also encoded in a visual form. This is further supported by Mayer et al. (1999:51) who argue that '… learners are better able to construct mental models when corresponding visual and verbal representations are in working memory at the same time. This situation is created when narration and animation are presented concurrently; and is hindered when the narration and animation are presented successively.'

As this theory (dual coding) was proposed to be used in multimedia design, it faced certain criticism. Ayers and Sweller (2005) and Sweller (1999:103) argued for the '*split attention effect'* in which inferior learning occurs when one's attention has to be divided between two information sources within one visual modality, for example, between visually presented animation plus simultaneous on-screen text. However, Clark and Mayer (2003) defended it by saying that 'in cases where students have difficulty understanding spoken words or if the pacing of the material is not fast, simultaneous audio and visual information may be experienced as non-redundant and over-loading may be avoided' (Debuse, Hede&Lawley, 2009:749). Kalyuga et al. (1999) further argued that when textual information is presented in auditory form, mental integration with a diagram may not overload working memory because working memory may be effectively expanded by using more than one sensory modality.

Moreno and Mayer (2007) look upon knowledge construction and learning as building mental representations. They maintain that the learner is a sense-maker who works to select, organize and integrate new information with existing knowledge. This is what they call deep learning. Their cognitive-affective theory of learning with media (Moreno 2005a) is an expansion of the theory of multimedia learning (Mayer, 2001; Moreno, 2005a) and is based on assumptions that: (a) Humans have separate channels for processing different information modalities (Baddeley, 1992); (b) Only few pieces of information can be actively processed at any one time in working memory within each channel (Sweller, 1999); (c) Meaningful learning occurs when the learner spends conscious effort in cognitive processes such as selecting, organizing and integrating new information with existing knowledge (Mayer & Moreno, 2003); (d) long-term memory consists of a dynamic, evolving structure which holds both, a memory for past experiences and a memory for general domain knowledge (Tulving, 1977); (e) Motivational factors mediate learning by increasing or decreasing cognitive engagement (Pintrich, 2003); (f) Meta-cognitive factors mediate learning by regulating cognitive processes and affect (McGuiness, 1990); and (g) Differences in learners' prior knowledge and abilities may affect how much is learned with specific media (Kalyuga et al., 2003; Moreno, 2004; Moreno &Durán, 2004).

From the theoretical framework and literature review above, the conceptual framework showing the relationship between the variables was derived. The independent variable was learners' conceptual understanding and the depended variable was the local language used in teaching physics.

3. Research Methodology

The chapter is divided into the following sub-sections; research design, population, sample and sampling procedure, research instruments, data collection procedure, data analysis, data interpretation, limitations and ethical considerations.

The researcher used the PhET interactive simulations to conduct virtual experiments in teaching friction to a selected group of students. The acronym "PhET" originally stood for "Physics Education Technology" but the software is now used in several other fields of science and mathematics. PhET simulations can be run online or downloaded as open-source (free) software.

They are interactive in the sense that they respond directly and immediately to input from the user.

The research design used in this study was pre-test post-test quasi experimental research design. This is in line with quantitative research methods which incorporates a natural science model of the research process which emphasizes quantification in the collection and analysis of data.

This research will employ a positivist paradigm. According toEaster-by (2008),positivism adheres to the view that only "factual" knowledge gained through observation (the senses), including measurement, is trustworthy. In positivism studies the role of the researcher is limited to data collection and interpretation in an objective way. In these types of studies research findings are usually observable and quantifiable.

According to Crowther& Lancaster (2008), Positivism depends on quantifiable observations that lead to statistical analyses. It has been noted that "as a philosophy, positivism is in accordance with the empiricist view that knowledge stems from human experience. It has an atomistic, ontological view of the world as comprising discrete, observable elements and events that interact in an observable, determined and regular manner"

Table 4.1.1 *Pre-test-post-test quasi experimental research design*

A. Treatment Group (taught using virtual experiments)	**O_1×**	**O_2**
B. Control group (taught without virtual experiments)	**O_3-**	**O_4**

Table 4.1.1 shows the pre-test-post-test quasi experimental research design

Of the two Physics classes there was one experimental group and one control group designated group HER A and HER B respectively. The two study groups were randomly selected the four classes at the college. Group HER A was exposed to the topic called Friction using Virtual experiments while group HER B only was taught the topic friction without virtual experiments.

Appropriate permission was obtained from the college authorities. It was also ensured that none of the topics to be treated in the study had been dealt with in any of the classes. After the administration of the pretest the experimental groups were taught the lesson using virtual experiments while the control group was taught without virtual experiments. The post test was administered to the students after the lessons had been taught.

THE RESEARCH POPULATION

This research was conducted at Northern Technical College (NORTEC) in the HER classes of Zambia. NORTEC is a leading engineering institution in technical and vocational training in Zambia. It offers technical vocational training from craft level to diploma level with courses ranging from; Mechanical, Electrical and Automotive & Heavy Equipment Engineering.

Two classes comprising 120 first year Heavy Equipment Repair Technician students were selected for this study. Simple random sampling procedure using a drawing method (with replacement) was employed. One of the classes became an experimental group, while the other one became the control group. The use of already existing classes was used so that there was no interference by the research with the school program by learners changing classes which had already been arranged by the school authorities.

Using a simple random sampling technique, each research class was randomly assigned to either the control or experimental group. The control group consisted of 60 randomly assigned participants and the experimental/treatment group consisted of 60 randomly assigned participants.

The population in question comprised respondents selected from HER A, HER B, HER C and HER D classes.

The population in question consisted of Two hundred and forty (240) respondents comprising pupils from the four classes; HER A, HER B, HER C and HER D classes.

Simple random sampling procedure using a drawing method (with replacement) was employed. One of the classes became an experimental group, while the other one became the control group. The use of already existing classes was used so that there was no interference by the researcher with the college program by learners changing classes which had already been arranged by the college authorities.

Chongo (2009) defined reliability as a measure of the degree to which a research instrument yields consistent results or data after repeated trials. In order to improve the reliability of the instrument, an assessment of the consistency of the responses on the pilot questionnaires was be made so as to make judgment on their reliability. Test-retest technique was administered twice to the respondents, with one week interval to allow for reliability testing.

On the other hand, validity of the instrument was enhanced through expert judgment. As such, assistance from the supervisors was relied upon.

This data was collected from published and unpublished data sources. This included documents from the Ministry of education, unpublished dissertations, internet, journals, magazines, books and articles. This data was collected by way of administering both open and closed questionnaire to the respondents who comprised Grade eleven pupils from the research sites.

Quantitative data will be generated by the study. Data analysis involves scrutinizing the required information and making inferences, Kombo & Tromp (2006). The student assessment tests (SAT), pre-test and post-test will be marked and marks recorded for each student. The mean of the experimental group will be compared to the mean of the control group using independent sample T-test. This will be used to address the study objectives and test the null hypotheses for the study.

The following hypotheses were tested.

H_0:| There is no significance difference in the performance of students taught using virtual experimental techniques and those taught by a conventional method.

H_1: Students who are taught using virtual experimental techniques perform better than those using a conventional approach.

Ethical consideration will be upheld during the study as the principles of confidentiality, anonymity and informed consent will be applied. Prior to carrying out the study, the researcher will seek permission from the college Principal and the head of department (Automotive and Heavy Equipment Repair). The researcher will explain to the college Principal and the head of department, the purpose of the study and the methods to be used in carrying out the study. Due to ethical issues, students in the control group will later be taught using virtual experiment techniques on friction so that they will get the same exposure before sitting for national examinations.

4. Data Presentation and Analysis

This chapter presents the results and analysis from the pre-test and post-test scores and from questionnaires. The results are presented in conformity with the research objectives and research questions. Furthermore, the data collected for this study were analysed with reference to the hypothesis stated. Each result presented is preceded by a brief analysis.

Table 5.1.1A: *Distribution of respondents by gender*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
Male	41	68.3
Female	19	31.7
Total	60	100

Table 5.1.1B:

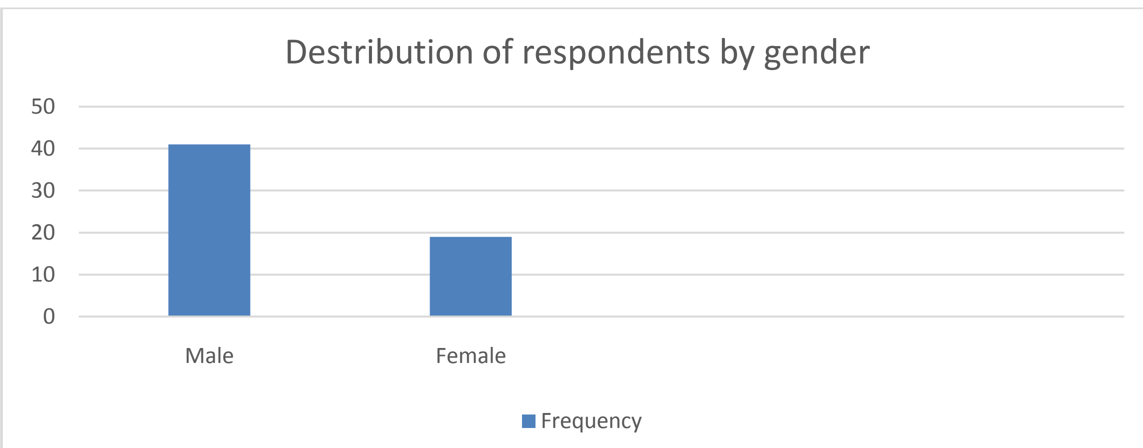

Figure 5.1.1 *Age range of respondents*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
18 - 20	22	36.66
21 - 30	31	51.66
30 - above	7	11. 66
Total	60	100

Tables 5.1.1A and 5.1.1B show that a total number of forty-one (41) participants representing 68.3% males and nineteen (19) participants representing 31.7% females were considered for the study at HER A Class. Further, we see from the table that the major respondent age group was from the 21 – 30 years.

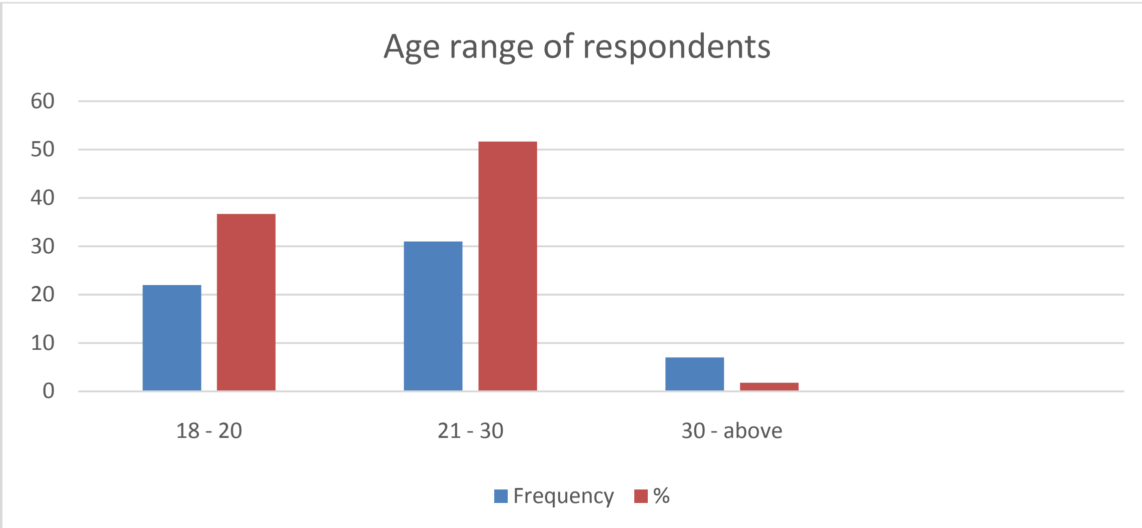

Figure 5.1.2 HER B CLASS

Table 5.1.2A: *Distribution of respondents by gender*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
Male	46	76.7
Female	14	23.3
Total	60	100

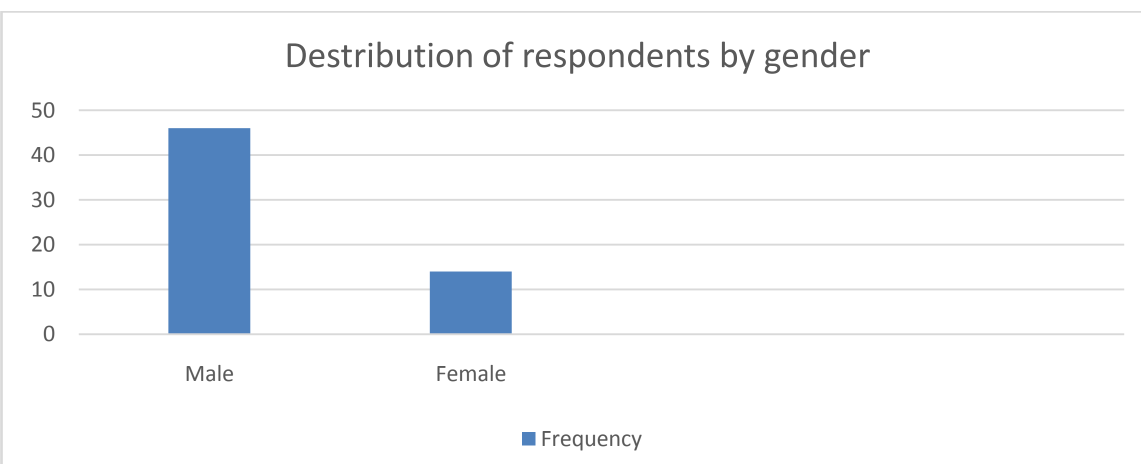

Figure 5.1.3

Table 5.1.2B: *Age range of respondents*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
18 - 20	39	65.0
21 - 30	17	28.33
30 - above	4	6.66
Total	60	100

Tables 5.1.2A and 5.1.2B show that a total number of forty six (46) participants representing 76.7% males and fourteen (14) participants representing 23.3% females were considered for the study at HER B Class. Further, we see from the table that the major respondent age group was from the 18 – 20 years.

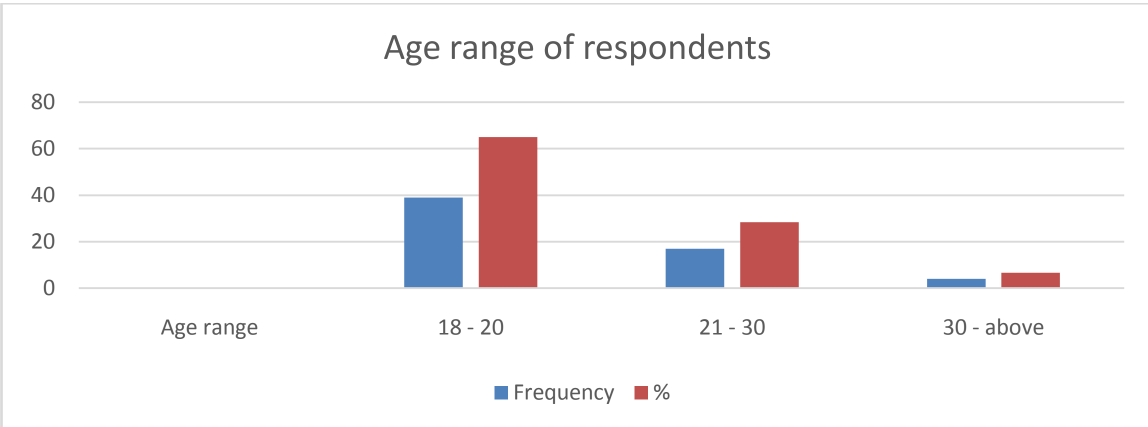

Figure 5.1.4

5.2 CUMULATIVE DEMOGRAPHIC CHARACTERISTICS OF THE ENTIRE RESEACH SAMPLE

Table 5.2.1A: *Distribution of respondents by gender*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
Male	87	72.5
Female	33	27.5
Total	120	100

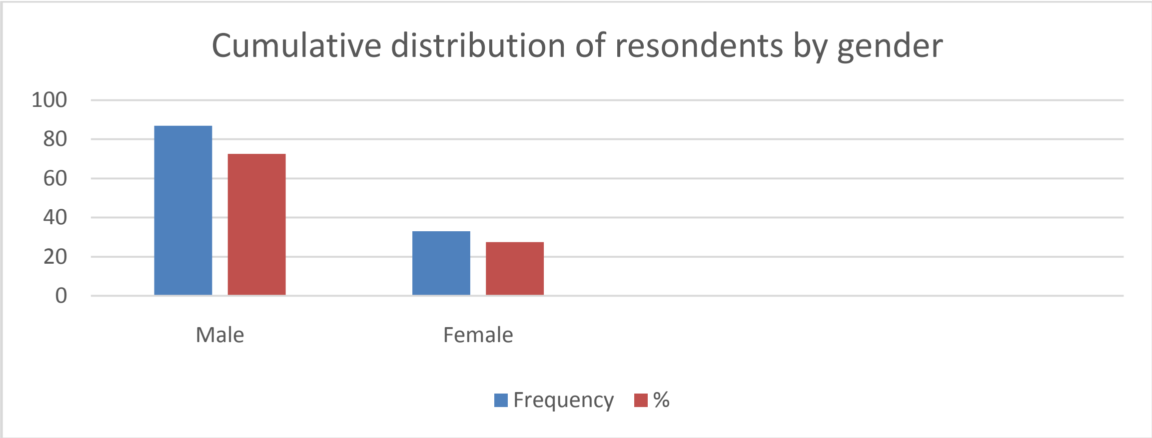

Figure 5.1.6

Table 5.2.1B: *Age range of respondents*

DESCRIPTION	FREQUENCY	PERCENTAGE (%)
18 - 20	61	50.8
21 - 30	48	40
30 - above	11	9.2
Total	120	100

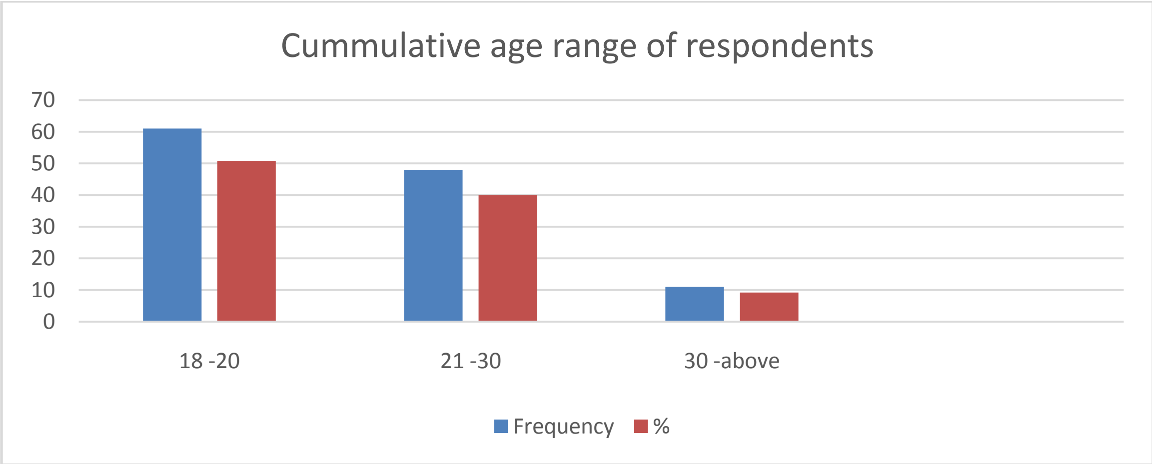

Figure 5.1.6

Tables 5.2.1A and 5.2.1B show that a total number of eighty seven (87) participants representing 72.5% males and thirty three (33) participants representing 27.5% females were considered for the study in the two selected classes of Nortec. Further, we see from the table that the major respondent age group was from the 21 – 30 years.

5.3 COMPARISONS OF MEANS AND STANDARD DEVIATIONS FOR EACH

5.3.1 HER A CLASS

Table 5.3.1: *Pre-test comparison between experimental and control group.*

Group Statistics

	Group1	N	Mean	Std. Deviation	Std. Error Mean
Pretest1	Experimental Group (HER A)	60	53.23	13.228	1.994

Group Statistics

	Group1	N	Mean	Std. Deviation	Std. Error Mean
Pretest1	Control Group (HER B)	60	48.29	16.795	2.591

Table 5.3.1 show Means (X) and Standard Deviations (S.D) of the Pre-test Scores for the Experimental (HER A) and Control (HER B) groups. The experimental group had a mean of 53.23%while the control group had a mean of 48.29%.

The difference in the mean scores for the experimental and control groups was 4.95. This entails that there was no significant difference between the performance of the experimental and the control group. Thus, this meant that at the beginning of the experiment, the two groups were the same.

The data obtained were further analyzed using independent t-test to verify the hypothesis.

Ho: states that there is no significant difference between the pretest and the posttest achievement scores of students taught by integrating a local language into Friction and those taught only with Friction as medium of instruction.

The t-test for the scores of the Experimental and control groups computed and the following results were obtained.

Table 5.3.2: *Independent sample t-test for the pre-test scores*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest1	Equal variances assumed	2.002	.161	1.520	84	.132	4.942	3.252	-1.525	11.408
	Equal variances not assumed			1.511	77.890	.135	4.942	3.270	-1.568	11.452

* Significant at P<0.05

Table 5.3.3 shows that the results from an independent samples t-test yielded a t-value of 1.520 and the p-value was 0.132

The difference was not statistically significant at t= 1.520, (p=0.132>0.05) because p-value (0.132) was greater than alpha level (α=0.05). Hence, the results suggest that there was no significant difference between the performance of the experimental and the control group. This meant that at the beginning of the experiment, the two groups were the same.

Table 5.3.4 *Post-test comparison between experimental and control group*

Group Statistics

	Group1	N	Mean	Std. Deviation	Std. Error Mean
Posttest1	Experimental Group (HER A)	60	67.30	11.619	1.752

Group Statistics

	Group1	N	Mean	Std. Deviation	Std. Error Mean
Posttest1	Control Group (HER B)	60	51.30	14.743	2.331

Table 5.3.4 shows Means (X) and Standard Deviations (S.D) of the Post-test Scores for the Experimental and Control groups. The experimental group had a mean of 67.30 while the control group had a mean of 51.30

The difference in the mean scores for the experimental and control groups was 16. Thus, this showed that there was a significant difference between the performance of the experimental and the control groups. This meant that the use of the Virtual experiments in the teaching and learning of Friction had a positive impact on the learners' conceptual understanding of Friction.

The data obtained were further analyzed using independent t-test to verify the hypotheses.

Ho: states that there is no significant difference between the pretest and the posttest achievement scores of students taught by integrating a local language into Friction and those taught only with Friction as medium of instruction.

The t-test for the post-test scores of the Experimental and English control groups were compared and presented in table 5.3.5.

Table 5.3.5: *Independent sample t-test for the post-test performance*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest1	Equal variances assumed	1.986	.162	5.548	82	.000	15.995	2.883	10.260	21.731
	Equal variances not assumed			5.486	74.062	.000	15.995	2.916	10.186	21.805

* Significant at P<0.05

Table 5.3.5 shows that the results from an independent samples t-test yielded a t-value of 5.548 and the p-value was 0.000

The results suggest that there was a significant difference between the performance of the experimental and the control group. This meant that at the end of the experiment, the two groups were the different in terms of performance.

This meant that the use of the Virtual experiments in the teaching and learning of Friction had a positive impact on the learners' conceptual understanding of Friction.

5. Results and Discussion

This chapter is a discussion of the findings of the study. The discussion is guided by the research objectives which were to: ascertain if teaching learners Friction using virtual experiments would improve their performance.

Overall, the results of the tests and the class observations indicated that respondents comprehended the concepts better if they were taught Friction using virtual experiments as compared to being taught without using virtual experiments. The student respondents who were taught using virtual experiments in the lesson responded better to their lecturers during class participation and in expressing their own ideas. The results of the post tests showed that the student respondents of those who were taught using virtual experiments in the lesson had better performance compared to those students who were taught only in Friction.

On average, the mean scores of the student respondents of those who were taught using virtual experiments in the lesson were considerably higher than those of student respondents who were taught without virtual experiments. Noticeably, the students' better performance when taught using virtual experiments seem to indicate that the students comprehended the concepts.

Students seemed to understand what their lecturers were teaching in class. Additionally, the students easily followed their lecturers' instructions during class activities.

Moreover, the results obtained revealed that most of the student respondents preferred using virtual experiments.

In summary, based on the results of the study, teaching using virtual experiments in Physics education was beneficial to the students who learned Friction. It significantly enhanced the learning outcomes of students in their communities and also improved the quality of lesson delivery. Besides, the findings revealed that the student respondents had better performance when taught Friction using virtual experiments in the lesson.

6. Conclusions and Recommendations

This chapter presents the conclusion and recommendations. In this study the intention was to ascertain if teaching learners using virtual experiments would improve their performance and to determine whether the labs and experiments on Friction could be easier to understand if they are explained using virtual experiments.

It was found that experimental groups performed better than the Control Group. One of the possible reasons for the performance could be attributed to the method of instruction. Simply put, the using of virtual experiments placed the experimental group at an advantage over the Control Group. It could be claimed that the use of virtual experiments as a medium of instruction contributed to the higher achievement of the experimental group.

Friction, a topic known to be difficult to teach and learnt due to lack of experimentation was taught and learned with relative ease using virtual experiments as a medium of instruction. If Physics educators are interested in inculcating the spirit of science in our students, if Physics educators do not want to be left behind in the global world for scientific and technological development, then it is imperative for all of them and all concerned educational administrators, curriculum developers, authors and policy makers to join forces in order to teach and learn Physics using a method that gives minimum difficulty to the students thereby making the desired results a reality.

Many colleges in Zambia lack the laboratories and necessary equipment required to effectively teach students in Physics. Therefore, many first year students at higher institutions of learning such as Northern Technical College have never performed or even seen an experiment being performed. (i.e. physical/ virtual). The lack of experimental techniques in colleges and higher learning institutions has led to little or no relevant knowledge about subject matter. The main purpose of the study is to identify the benefits and challenges associated with using virtual experimental techniques and factors to consider when planning the development and implementation of virtual laboratories at Northern Technical College. This study aims to analyse the impact of virtual experimental techniques as a tool in supporting students to increase their active learning of friction as well as an effective teaching aid for lecturers. Despite the government's commitment to education, the quality of education in our colleges has been declining tremendously, thereby giving successive government's serious concern. The following recommendations are made for future researches on the use of virtual experiments as a medium of instruction when it comes to teaching of Physics in colleges.

The results of this study showed that teaching learners using virtual experiments had significant effects on the learners' conceptual understanding. Thus, considering all the advantages that the using virtual experiments brought into the experimental groups, lecturers of Physics in Zambian should consider using this approach in their teaching. This may provide learners with a better understanding and permanence of the concepts being taught. Subsequently, this may improve learners' results in physics examinations on topics such as Friction and many others.

Furthermore, the lecturers of Physics should consider using virtual experiments as a media of instruction in teaching of physics. In this way lecturers may make their Physics teaching more effective so that learners are provided with a better understanding of the concepts. The study of using virtual experiments in teaching Friction is one of its kind. Therefore, continued researches are needed to be carried out so as to implement this technique in other topics in the subject of physics.

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