Efficacy of Demonstration-Guided Simulations on Male and Female Learners' Conceptual Understanding: Lessons from Electromagnetic Induction in Selected Secondary Schools of Lusaka District

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ABSTRACT

This study aimed at evaluating the effectiveness of Demonstration-Guided Simulations (DGSs) on students' understanding of Electromagnetic Induction. The study used a pre-test-post-test quasi-experimental approach with a Solomon four design on a sample of 132 secondary school students. Physics Achievement Test (PAT) was used to collect data, and the experimental and control groups were pretested before being taught Electromagnetic Induction using Faraday's Electromagnetic Lab simulation or the traditional method respectively. All groups were then post-tested, and data was analyzed using independent samples *t*-tests for experimental and control groups. The study found that DGSs significantly improved student performance, with all experimental groups performing better than the control groups. Additionally, the simulations were found to be gender-friendly, as girls from the experimental group performed significantly better than those from the control group. The study concluded that the use of demonstration-guided simulations is more effective than traditional instruction methods and should be encouraged. The study recommended that the Curriculum Development Centre may incorporate DGSs into the curriculum, that the Ministry of General Education may include simulation training in teacher education programs, and that schools and district administrators may develop professional development programs on the integration of simulations into teaching.

Keywords: Computer simulations, gender, Physics, Electromagnetic Induction, abstract concepts

INTRODUCTION

Science is one of the subjects that is poorly performed at grade 12 National Examination and the current situation regarding learners' performance in physics to be specific leaves much to be desired especially that of girls in comparison with the boys. With regard to poor performance by girls in physics compared to boys, some scholars have attributed this to the negative attitude which most girls have towards science and mathematics. Kafata and Mbetwa (2016) and Maguswi (2012) both noted that female students in Zambia and worldwide perform badly in O-level Physics both in class and at national examination. In all these findings, the traditional method of instruction was found to be the most dominantly used. This method of instruction has a major focus on the teacher's skills, knowledge and understanding of the subject matter and it also focuses on remember and understand, which are the low order thinking level of Bloom's taxonomy.

An alternative method proposed in this research is the use of technology, specifically simulations in the delivery of lessons. According to (Haamoonga, 2017), the Zambian government has over the years tried to provide an environment that would improve learner performance, such as reducing class size, providing adequate learning materials and upgrading teacher qualifications, but not much success has been recorded. As can be seen in Tables 1 and 2, the performance of learners in physics between 2013 and 2017 had been

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very poor, falling way below 50%.

Table 1: Mean performance (%) in Science (5124) per paper (From 2013 to 2017)

	2013	**2014**	**2015**	**2016?**	**2017?**
Paper 1 (Physics/Chemistry)	55.40	33.10	33.07	***17.05***	***37.01***
Paper 2 (Physics)	***13.71***	***9.72***	***8.74***	43.95	38.79
Paper 3 (Chemistry)	40.88	16.30	17.0	42.24	23.80
Total (%)	33.94	17.76	17.65	32.83	35.28

Source: Examination Council of Zambia

∗ In 2016 and 2017, the format of papers changed according to the new syllabus, with paper 1 being physics, paper 2, chemistry and paper 3 is practical (Physics and chemistry)

Table 2: Mean performance (%) in Physics (5054) (From 2013 to 2017)

YEAR	2013	2014	2015	2016	2017
PERFORMANCE (%)	48.28	48.33	48.83	38.59	44.34

Source Examination Council of Zambia

One of the topics which is poorly performed by learners nearly every year in physics is electromagnetic induction (ECZ, 2013, 2014, 2015, 2016, 2017).

A number of researchers have suggested means and ways of improving learner's performance in science subjects, particularly in physics. According to Kapata (2017), rearrangement of topics where candidates performed poorly such as radioactivity, electromagnetic induction and electronics and consideration of their prerequisites might enhance the performance of learners in physics. The findings of this study indicated that science scholars perceive the rearrangement of some physics topics as one of the ways which might enhance the performance of learners. Physics is one of the many fields of science that relates frequently to people's everyday lives. It is considered as the study of matter, energy and their various interactions. Electromagnetic Induction (EMI), which is a component of physics is defined as the process by which an electromotive force is generated across an electrical conductor in a changing magnetic field. The concept behind EMI has fashioned a great revolution in the field of engineering applications which further influenced other fields such as space exploration, industrial applications, medicine to mention but a few. Some of the many applications of EMI at domestic level are found in most electrical appliances which use transformers, appliances such as hair blowers, computers, mobile phone chargers and in agriculture it is used in soil investigations (Doolittle & Brevik, 2014). It can therefore be seen that EMI is capable of creating essential knowledge required for the future technological advances that will drive the economic engines of countries and the world at large. That is why it must be emphasised that concepts in physics like those of EMI are presented in an interesting and engaging way for the learners to develop the interest and passion for the subject and have a better understanding of such concepts. One way of doing this is by utilising the power of technology in teaching, specifically the use of computer simulations. It is hoped that once the interest and passion for the subject is inculcated into the learners, it will further improve their performance in the subject. EMI, like a few others contains a lot of abstract concepts which must be presented in a way that simplifies them so that learners are able to understand them easily (Dori & Belcher, 2005). Learners usually find it difficult to visualise such abstract concepts and their processes especially that when teaching, most teachers present such topics with limited or no visual aids. In instances where teaching aids are used, they are usually static images which are limited because they do not represent the complete picture of a real-life process being taught and learners are unable to explore and interact with them.

A simulation is a mathematical model that describes or creates computationally a system process. Simulations are our best cognitive representation of complex reality, that is, our deepest conception of what reality is (Vallverdú, 2014). From this definition, it becomes easy to note that introducing simulations in teaching may offer learners the opportunity to make more sense out of the concepts being presented to them because they connect reality to what is being presented. Digital technologies can help to facilitate knowledge acquisition and understanding in this context (Moser, Zumbach & Deibl, 2017). Since there are so many simulations which are used for educational purposes, in this study, the researcher used a Physics Education Technology (PhET) Simulation titled Faraday's Electromagnetic lab (*v 2.07*). The Physics Education Technology (PhET) Project is a suite of online and offline open source of simulations for teaching and learning introductory physics, mathematics and other sciences at high school and college levels. Compared to other educational media such as textbooks or animations, opportunities for learners to interactively manipulate different scientific variables and observe the results in graphical representations like graphs or tables are crucial for knowledge acquisition (Moser et al., 2017).

In an ideal situation, students are expected to explore these simulations on their own with minimal guidance from the teacher. But it is worth noting that in a Zambian context and in most developing countries, most public schools are not adequately equipped with enough computers to carter for each and every student during the exploration of these simulations (Mwansa, 2022). As a result, demonstration-guided simulations were used in this study, where the teacher used a projector and demonstrated the working of particular simulations while engaging the learners during the exploration.

The use of computer simulations is beneficial to both the teacher and the student as it offers idealised, dynamic and visual representations of physical phenomena and experiments that might be hazardous, stressful, expensive or otherwise not feasible in school laboratories. (Oladejo, Nwaboku, Okebukola & Ademola, 2021). A scientist approaches research as an enjoyable opportunity to explore basic concepts, as well as to challenge, correct, and add to his or her understanding of how the world works. Similarly, the student usually finds exploring the simulations fun and, through this exploration, discovers new ideas about the science (Wieman, Adams & Perkins, 2008). This is the more reason why the teaching of science should be done in such a way that it provides learners with a platform and an opportunity to express their scientific ideas in an all embracing and interactive manner. Computer simulations are applications of special interest in physics teaching because they can support powerful modelling environments involving physics concepts and processes (Jimoyiannis & Komis, 2001). To the learners, they are able to provide correct mental models on which they can build new knowledge. This is because in the absence of proper visual and/or verbal cues, the brain will create 'mental pictures' which are based upon one's schema so as to add context to what is being learnt. For learners to develop correct schemata, they ought to learn concepts (*topics*) in correct and appropriate ways which are relevant and meaningful to them. That is why simulations offer one of the best instructional alternatives for learners. This is because the presented information will offer learners more realistic imagery of correct concepts being learnt. Simulation are designed to help students to learn to achieve specific objectives actively rather than passively (Bello, Ibi & Bukar, 2016). These characteristics of simulations make it possible to have a lively classroom environment that is capable of arousing and sustaining learner's interests and attention throughout the lesson time. It equally makes it possible to easily comprehend abstract concepts because each and every aspect that a simulation presents, corresponds to some aspect of a real life situation that is presented in a simplified way. These are elements which cannot be found in other methods of instruction such as the traditional one.

Dori and Belcher (2005)strongly believe that teachers and students need to incorporate visualizations in the teaching and learning of scientific phenomena and processes, especially when dealing with abstract concepts such as electromagnetism.

While many educators find it appealing to use simulations in their classroom, very little research has been done to determine if simulations improve a student's understanding of or enthusiasm for science and how simulations can be designed and used most effectively (Adams et al., 2008, p.2). According to Dervi?, Glamo?i?, Gazibegovi?-Busuladži? and Meši? (2018), external visualisations may facilitate physics learning by: highlighting elements that are most important to understanding the underlying physics concepts, conveying abstract information and providing a vivid context for testing hypotheses and solving problems. This is true because a number of physics concepts are very abstract to be effectively communicated to the learners without use of appropriate models or teaching aids. Simulations in general are able to bring out these external visualisations and make proper connections between concepts being presented and real-world situations or processes. Therefore, in order to effectively communicate concepts, it is important to make sure that these simulations are capable of helping the learners to concentrate on vital features of a particular concept and bridging the gap between real-life and abstract concepts. One other important feature of simulations is that learners are capable of exploring the simulations and hence establish cause and effect relations of some physics concepts, this helps in the effective construction of appropriate mental models (Dervi? et al., 2018). A simulation must be very simple and capable of offering an opportunity for effective knowledge construction. PhET simulations are some of the best simulations which are designed to reduce cognitive overload (Kaheru & Kriek, 2016). With PhET simulations, learners are able to effectively see the effects on one variable when another is changed in a more realistic manner.

According to Wieman et al. (2008), there are a number of characteristics that make a simulation fun and intellectually engaging, these include;

(i) dynamic visual environments that are directly controlled by the user, (ii) challenges that are neither too hard nor too easy, and (iii) enough visual complexity to create curiosity without being overwhelming. Items (ii) and (iii) are best developed through iteration and testing with students.

They further argued that most of the learning occurs when the student is able to ask questions that will guide his/her exploration of the simulation and discovery of the answers. This is because students learn better when they are engaged in self-driven explorations.

FINDINGS FROM OTHER STUDIES

Empirical results on the effectiveness of simulations on the performance of learners are quite mixed. According to a research conducted by the PhET project team on the design and use of simulations in a variety of educational settings, students who did a 2-hour exercise using the "Circuit Construction Kit" simulation in one semester course demonstrated higher mastery of the concepts of current and voltage on the final examination than students who did a parallel laboratory exercise with real equipment (Wieman et al., 2008). Their findings showed how effective the simulation was in helping learners understand the concepts in comparison with the traditional laboratory activity. On the other hand, Dervi? et al., (2018) compared the conceptual understanding of upper secondary learners taught physics using the teacher-centred simulation and the student-centred simulation approaches. The student-centred method adopted a constructivist approach, keeping in mind that learners must construct their own knowledge as they interact with the simulation, of course with minimal guidance from the teacher. However, contrary to the researcher's predictions, the learners from the teacher-centred group out-performed those in the student-centred group. These finding were in support of the findings of Kirschner, Clark and Sweller (2006) who argued against effectiveness of constructivism in class, but stated that there is much empirical evidence that guided instruction is generally more effective compared to minimal guidance approaches. Likewise, Wu and Huang

(2007) compared teacher-centred and student-centred use of simulations in teaching ninth grade students. Their findings suggested that both instructional approaches promoted students' conceptual understanding and provided students with different opportunities to engage in science learning. There was no significant difference in the performance of the two groups. On the contrary, when used as a lecture demonstration, the "Wave on a String" simulation resulted in greater conceptual learning than did the standard demonstration (Perkins et al., 2006). In a different study conducted in Nigeria, Adegoke and Chukwunenye (2013) compared computer simulated experiments and hands on experiments in improving student's learning outcomes in practical physics. They compared three groups; group one, taught using both computer simulated experiments and hands-on experiment, group two, taught using computer simulated experiments alone and group three, taught using hands-on experiments alone. Their findings showed that, the first group performed significantly better than the other two while the third group performed the worst. This shows that when the use of simulation in teaching is done collectively with other instructional approaches, the resulting effects are significantly maximised.

According to Ankiewicz, Rensburg & Myburgh (2001), when it comes to the aspect of gender, findings on the effect of gender on the use of simulations are equally mixed, with some showing significant differences in performance between male and female learners, while other studies found no significant differences. According to a study by Gamabri and Ikusanu (2014), there was no significant difference in performance between boys and girls when a computer based simulation was used in teaching them Physics. Their findings were consistent with those of Yusuf and Afolabi (2010) who, in their study, further investigated the influence of gender on the performance of students in biology after being exposed to computer assisted instruction. Their research found no significant difference in the performance of male and female students. However, other studies suggest otherwise on this aspect. Research conducted by Geelan & Mukherjee (2011), yielded contrary results showing huge significant differences between male and female learners with the males still outperforming their female counterparts. They only justified the use of simulations in teaching and learning on grounds of other benefits which they offer such as enjoyment of lessons. According to them, their findings warranted further investigations into the subject matter.

Almasri (2022) looked at understanding the connection between learners' engagement and satisfaction with simulations for science learning and their learning styles. The results of this study indicated that there was a significant difference between male and female learners in their level of engagement and satisfaction towards simulations in science learning. Female learners reported a significantly higher level of engagement and satisfaction with simulations in science learning than their male counterparts. With all these mixed findings on use of simulations in the classroom, it remains unclear how impactful simulations are on the performance of learners especially when they are used a demonstration. Hence the need for further investigation in the matter. The idea of using simulations in a demonstration manner is hinged on the premise that in most real situations, not every learner can have access to a computer and effectively manipulate the different parameters in a simulation during a particular lesson. This happens to be the prevailing situation in most public schools due to inadequate resources such as computers and internet connectivity (Mulauzi et al., 2020;Mwansa, 2022&Nkhoma, 2019). At times the teacher may be required to carry out demonstrations while manipulating a number of parameters in the simulation. In such a situation, the whole simulation program is projected on a big screen for every learner to see. According to Wieman et al. (2010), a simulation can be used as a simple animated illustration, in concept tests or in form of interactive classroom demonstrations. As an animated illustration, the simulation shows the process and can be slowed or sped up depending on the concept being shown. This allows effective classroom management by the teacher in the sense that the teacher controls the running of the simulation. To make it more interactive, learners can be engaged in concept test where the teacher asks a question in line with the concept at hand. Learners are then allowed to discuss with their neighbours and vote on the answer. Perhaps the most effective way to use simulations in a lecture is to begin with the teacher posing a scenario and asking students to write down their predictions, after students have written down their predictions, they talk with their neighbours to come up with final prediction for their group. The teacher then asks to hear predictions from the class and then runs the simulation. After students see what the simulation does, they write down what did happen and how it was different from their predictions. Finally, there is a whole class discussion about what they saw and why it makes sense based on physics ideas (Wieman et al., 2010). This happens to be one of the best ways to use simulations in a demonstration manner as it gives the teacher enough control of the classroom situation so as to effectively manage the learning process while actively engaging the learners. In a study to compare the teacher-centred approach and the student-centred approach in teaching physics using simulations, Dervi? et al., (2018) found that students in the teacher-centred group significantly outperformed their counter parts in the student-centred group on the post test. This can be attributed to the fact that in the teacher-centered approach, the teacher is able to give the appropriate minimal guidance to the learners unlike in a situation where the learners interact with the simulation on their own as is the case for the student-centered approach.

Research Questions

The following were the research questions for the study

1. What is the difference in academic performance between learners taught electromagnetic induction using demonstration-guided simulations as a supplement to traditional instruction and those taught using the traditional method?
2. How do male and female learners perform after teaching them electromagnetic induction using demonstration-guided simulations?
3. How do female learners taught electromagnetic induction using simulations perform compared to female learners taught using the traditional method?

Research Hypotheses

Emanating from the above research questions were the following Null and Research Hypotheses which were tested at 0.05 level of significance:

Research Question 1 Hypotheses

$H_0$1: There is no statistically significant difference in performance between learners taught using demonstration-guided simulations as a supplement to traditional instruction and those taught using the traditional teaching method.

H_A1: Learners taught electromagnetic induction using demonstration-guided simulations as a supplement to traditional instruction will perform statistically significantly better than learners taught using the traditional teaching method.

Research Question 2 Hypotheses

$H_0$2: There is no statistically significant difference in performance between male and female learners taught electromagnetic induction using demonstration-guided simulations.

H_A2: Male learners will perform statistically significantly better than female learners after teaching them electromagnetic induction using demonstration-guided simulations.

Research Question 3 Hypotheses

$H_0$3: There is no statistically significant difference in performance between female learners taught electromagnetic induction using simulations and female learners taught electromagnetic induction using the traditional method.

H_A3: Female learners taught electromagnetic induction using simulations will perform statistically significantly better than female learners taught electromagnetic induction using the traditional method.

Conceptual framework

In this study, the use of demonstration-guided simulations as an instructional method has been conceptualised as an independent variable that may affect the conceptual understanding of learners. This may lead to a change in performance on test score results, which is the dependent variable. Interaction of learners through the simulation activities, minimal guidance and scaffolding from the instructor (teacher) are treated as moderating variables which may influence the strength of the relationship between the independent variable (teaching using demonstration-guided simulations) and dependent variable (conceptual understanding, to be determined by test score results).

METHODOLOGY

A quantitative research paradigm was employed in this study. This is because the researcher was investigating the effect of an intervention (*demonstration-guided simulation*) on learners' conceptual understanding of electromagnetic induction. The study looked at a cause and effect relationship which was investigated quantitatively. According to Campbell, Stanley, and Gage (1963), an experiment is that portion of research in which variables are manipulated and their effects upon other variables observed.

The research design adopted for this study was quasi-experimental pre-test/post-test control group solomon four design. This design has a high reputation and represents the first explicit consideration of external validity factors (Campbell et al., 1963).

A summary of the research design and how it was conducted is shown in Table 3.

Table 3: Summary of the Design

Groups	Pre-test	Independent Variable	Post-test
Experimental group**(E_1)**	Y_1	X	Y_3
Control group**(C_1)**	Y_2	T	Y_4
Experimental group**(E_2)**		X	Y_5
Control group**(C_2)**		T	Y_6

Where,

Y_1refers to the pretest scores of the experimental group(E_1)

Y_2refers to the pretest scores of the control group(C_1)

Y_3refers to the posttest scores of the experimental group(E_1)

Y_4refers to the posttest scores of the control group(C_1)

Y_5refers to the posttest scores of the experimental group(E_1)

Y_6refers to the posttest scores of the control group(C_2)

X refers to the use of demonstration-guided simulations as a supplementary teaching method to the traditional method

T refers to the use of traditional teaching method only

In this study, the independent variables were; teaching using demonstration-guided simulations as a supplement to the traditional method while the dependent variable was the achievement scores which learners obtained after the posttests. Gender was a moderating variable.

The research was conducted in Lusaka district of Zambia in four co-educational secondary schools.

The sampled schools were given pseudo names as follows:

Alpha School, was experimental group 1 (E_1)

Beta School, was experimental group 2 (E_2)

Gamma School, was control group 1 (C_1)

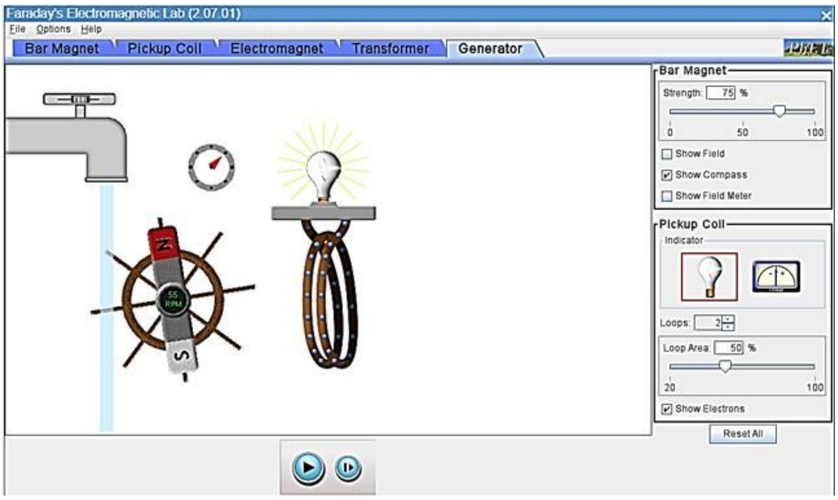
Delta School, was control group 2 (C_2)

The study sample consisted of approximately 132 grade 12 learners, of which 37 came from Alpha School, 26 came from Beta School, 33 came from Gamma School and 36 came from Delta School.

The research instrument used to collect primary data was a Physics Achievement Test (PAT) which was subjected for validation and reliability test. A reliability coefficient of was obtained from the pilot test using Kuder Richardson (KR-20). It consisted of 21 multiple choice items, ranging from definition of terms and processes, identification of correct abstract concepts and some calculations.

Figure 2 below shows an extract of the PhET simulation that was used in the teaching and learning process for the experimental group.

Figure 2: Extract of Faraday's Electromagnetic laboratory simulation



(https://phet.colorado.edu/en/simulations/faraday)

Data collection involved pretesting, teaching and post testing. It was collected in two phases.

Phase 1 (3 weeks): Data collected from the first two schools.

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The researcher collected data in one school where the intervention (treatment) was used, in the experimental group while a research assistant (*a physics teacher*) collected data from the other school were the traditional method of instruction was used.

Phase 2 (3 weeks): Data Collected from the last two schools

Again, the researcher collected data in one other school were the intervention (treatment) was used while a second research assistant (*a physics teacher*) collected data from the other school were the traditional method of instruction was used.

Firstly, pre-tests were administered in the first week to the experimental group () and control group using the (PAT). From the second to the third week, the lessons were taught to the experimental group () and control group with the PhET simulations used as a supplementary teaching method in the experimental group () and the traditional method used in the control group . At the end of the third week, the two groups were post-tested. This was done in phase 1.

In phase 2, starting in the fourth week, experimental group was taught using the PhET simulations as a supplementary teaching method, without being pretested. Control group was also taught but using only the traditional method. This went into the fifth week and at the end of the teaching cycle, these two groups were also post-tested. All the four groups had a time allocation of two periods of 40 minutes each week.

The collected data was analysed using descriptive and inferential statistics specifically independent samples t-tests were carried out using SPSS version . All the statistical tests were evaluated at level of confidence.

RESULTS

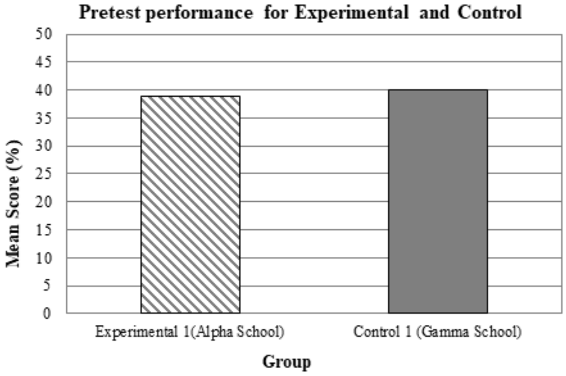
From the four groups in the design, the Experimental group 1 **,** from Alpha School and Control group 1 **,** from Gamma School were both pre-tested and the results show that there was no statistically significant difference between the mean score of , and , ; ,.

Table 4 shows independent samples t test results conducted on the results for and given in Table 4.

Table 4: Independent samples test for (Alpha School) and (Gamma School) Pretest

Groups	*N*	*t*	*CV*	*Df*	*p – value*	Mean difference	Cohen's *d*
	35	0.306	2	59.765	0.760	0.561	0.036
	33						

Figure 3: Pretest performance for Experimental group and Control group



These results showed that the groups where at the same level of comprehension on the topic before treatment.

$H_0$1: There is no statistically significant difference in performance between learners taught using demonstration-guided simulations as a supplement to traditional instruction and those taught using the traditional teaching method.

To test this hypothesis, an independent samples t-test was conducted and Table 5 shows the results

Table 5: Independent samples t test results.

GROUPS	*N*		*CV*	*df*	*p – value*	Mean difference	Cohen's *d*
	30 28	3.466	2.004	54.895	.001*	14.712	.913
	30 36	2.060	2.003	55.780	.044*	7.283	.518
	26 32	3.767	2.009	49.918	0.00043*	18.409	1.031
	26 36	2.562	2.02	40.568	.014*	10.981	.7026

*Significant at

The data presented above shows that both experimental groups performed statistically significantly better than the two control groups with a medium to large effect size of the intervention.

$\boldsymbol{E_1}(M = 66.03, SD = 15.54)$ performed better than $\boldsymbol{C_1}(M = 51.32, SD = 16.7;$

$t = 3.466, p = .001, d = .913)$.

$\boldsymbol{E_1}(M = 66.03, SD = 15.54)$ performed better than $\boldsymbol{C_2}(M = 58.75, SD = 12.65;$

$t = 2.06, p = .044, d = .518)$.

$\boldsymbol{E_2}(M = 69.73, SD = 19.02)$ performed better than $\boldsymbol{C_1}(M = 51.32, SD = 16.7;$

$t = 3.767, p = .00043, d = 1.031)$.

$\boldsymbol{E_2}(M = 69.73, SD = 19.02)$ performed better than $\boldsymbol{C_2}(M = 58.75, SD = 12.65;$

$t = 2.562, p = .014, d = .7026)$.

From all these findings, all values are less than and all values are greater than their corresponding critical values, therefore, learners taught electromagnetic induction with simulations performed statistically significantly better than those taught using the traditional method. Therefore, the first null hypothesis has been rejected.

H_0^2: There is no statistically significant difference in performance between male and female learners taught electromagnetic induction using demonstration-guided simulations.

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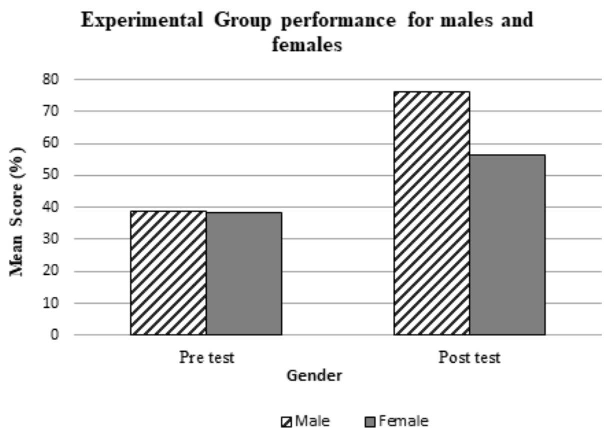
To test this hypothesis, an independent samples t-test was conducted and Table 6 shows the results.

Table 6: independent samples t test results between males and females for experimental group

EXPERIMENTAL GROUP 1	*N*	Mean		*CV*	*df*	*p – value*
Pretest	18	39.50	.	2.034	33	.796
	17	38.35				
Posttest	18	72.33	3.16	2.048	28	.004
	12	56.58				

The results from the independent samples t test show that after teaching both of them using simulations, males , performed significantly better than females , ; ,. Therefore, the second null hypothesis, has been rejected.

Figure 4: Pre and Post-test performance for males and females in Experimental group



$H_0$2: There is no statistically significant difference in performance between female learners taught electromagnetic induction using simulations and female learners taught electromagnetic induction using the traditional method.

To test this hypothesis, an independent samples t-test was conducted and Table 7 shows the results.

Table 7: Independent samples t-test results between males and females for control group

	CONTROL GROUP 1	*N*	Mean		*CV*	*Df*	*p – value*
Pretest		13	51.54	3.693	2.061	24.706	
		20	32.60				
Posttest		13	59.38	2.608	2.061	24.65	
		15	44.33				

From the results in table 7, it can equally be observed that after teaching them using the traditional method only, once again males, performed significantly better than females , ; ,. Therefore, the third null

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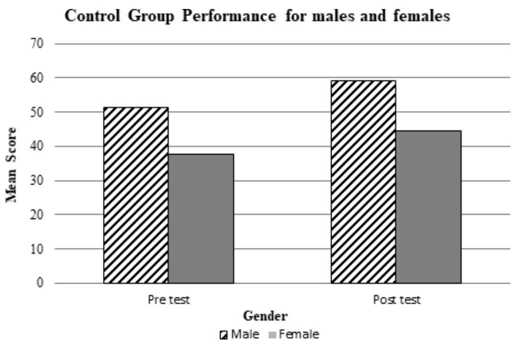
hypothesis, has equally been rejected.

Figure 5: Pre and Post-test performance for males and females in Control group



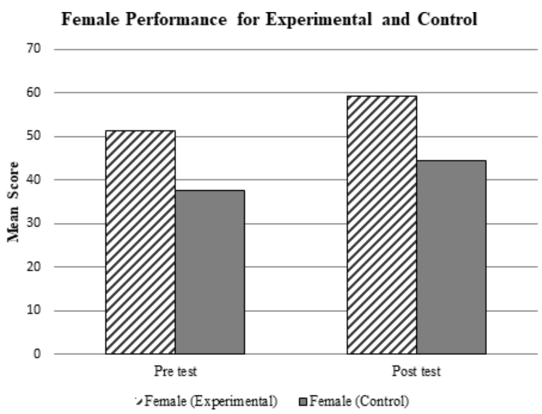
To further investigate the impact of gender on the use of simulations, the performance of female learners from the experimental group was compared with those of the control group and the results are shown in table 8 below

Table 8: Independent samples t test results between females in experimental group and females in control group

GROUP	*N*	Mean			SD		*CV*	*df*	*p – value*
		Pre	Post						
Experimental 1 (Female)	15	38.35	56.58	12.82	2.325	2.061	24.711	.029	
Control 1 (Female)	12	37.62	44.33	14.519					

The results from table 8 above reveals that females in the experimental group , performed significantly better than females in the control group , ; ,.

Figure 6: Pre and Post test performance of females in Experimental and Control groups



DISCUSSION

Effectiveness of Demonstration-Guide Simulations (DGSs)

The results of the study revealed that when used as a supplementary teaching method to the conventional traditional method, demonstration-guided simulations (DGSs) where able to enhance learner's performance. This is so because the learners from the groups exposed to DGSs as a supplement to traditional instruction performed statistically significantly better than their counterparts taught only using the traditional method in the control groups. Their good performance can be attributed to the constructivist nature of the lessons which was provided by the simulations. Since all learning is a process of discovery, it is worth mentioning that in a constructivist learning environment, development in cognition and improvement in conceptualization largely depends on the process used to internalize the knowledge. As such, the use of computer simulations and other multi-dimensional environments are seen to be more powerful than those which are used in conventional learning environments (Gönen, Kocakaya, & Inan 2006). Being a social progression, learning involves language, real world situations, and interaction and collaboration among learners. These are some of the elements which computer simulations bring out during the process of learning. The socio-constructivist classroom created by the use of demonstration-guided simulations had substituted the role of the teacher from being an instructor (*as is the case in a traditional method of instruction*) to that of a facilitator and in this case, the learner became the centre of classroom activity. According to Mhlongo, Dlamini and Khoza (2017), the socio-constructivist approach emphasises the active construction of knowledge through the use of technology-based tools merged with social practices.

These findings of this study are seen to be consistent with those of a number of researchers. Kaulu (2011) found that the use of simulations enhanced learner's performance when used as a supplement in the teaching and learning process. His findings showed that the use of the Physics Classroom Computer Software enhanced the performance of learners in Kinematics more than when traditional approaches were used. Similar finding from a good number of other researchers have shown that the use of computer assisted instructions and simulations in particular, always enhance the performance of learners in a number of subjects (Adegoke & Chukwunenye, 2013; Kirschner et al., 2006; Perkins et al., 2006; Wieman et al., 2008; Wu & Huang, 2007). This therefore shows that the use and integration of simulations in teaching as a supplement to the traditional method can address and solve the challenge of learner's poor performance in science and physics in particular. It should be noted that all the researchers used simulations in their studies in different ways but similar results were produced. Some compared conventional experiments and simulated experiments(Adegoke & Chukwunenye, 2013), others compared teacher-centred use of simulations and student-centred use of simulations (Dervi? et al., 2018) and others compared teaching using simulations and teaching using standard demonstrations (Perkins et al., 2006).

In this study the comparison was done between the use of simulations in a demonstration manner with the teacher running the simulations and the use of the conventional traditional method of teaching. As stated earlier in all these instances, simulations did enhance the performance of learners to a significant extent.

Impact of gender on the use of simulations

Lastly, the study tried to investigate whether gender differences had an impact of the use of Demonstration-Guided Simulations (DGSs). The study revealed that there was a significant difference in performance between male and female learners. It was found that male learners performed statistically significantly better than their female counterparts in the two experimental groups where demonstration-guided simulations were used. The results are in accord with those of Gambari, Obielodan and Kawu (2017), who found that there was a significant difference in the mean achievement scores of male and female students with males performing better than females when they were all taught chemistry using the virtual laboratory simulation in an individualized setting. In another study by Gamabri, Kawu and Falode (2018), male students performed statistically significantly better than their female counterparts in both homogenous and heterogeneous groups where virtual labs where used in collaborative environments.A study by Geelan, Ebner, Bastiaens and Mukherjee (2011), equally showed huge significant differences between male and female learners with the males outperforming their female counterparts when simulations when were used in teaching physics and chemistry.

The findings of this study are equally consistent with the Examination Council of Zambia (ECZ) report on general performance in Science and Physics which indicates that the performance of male learners in

Science and Physics is better than that of female learners (ECZ, 2013, 2014, 2015, 2016, 2017).

On the contrary, other researchers have found the use of simulations to be gender friendly. Gambari, Shittu, Falode and Adegunna (2016) found that the use of Computer Self-Interactive Package (CSIP) in mathematics was gender friendly. In their study, there was no significant difference in terms of performance between male and female learners when the CSI Package was used. On average, the female learners performed as good as their male counterparts. Similarly, Falode, Falode, Usman, Sobowale and Saliu (2015) who investigated effectiveness of Computer Simulation Instructional Package on secondary school Geography students' achievement in map reading found that there was no significant difference in performance between male and female learners.

While the performance of the females in this study was statistically significantly lower than that of males within the experimental group, the females from the experimental group performed statistically significantly better than the females from the control group. This therefore shows that the use of demonstration-guided simulations in teaching still remains gender friendly as it enhanced the general performance of the female learners in the experimental group.

CONCLUSION

The main objective of the study was to establish the efficacy of DGSs on learner's conceptual understanding of Electromagnetic Induction. The study established that learners from experimental groups who were exposed to the use of DGSs performed significantly better than those in the control groups taught using the traditional method only where the lecture method was predominantly used. Based on these findings, it can be concluded that the use of DGSs in teaching Electromagnetic Induction is able to produce conceptual understanding and can therefore lead to enhanced learner performance. When it comes to gender differences, the use of simulations was still considered to be gender friendly even though statistically, male learners performed better than female learners. This is because the female learners in the experimental group managed to perform statistically significantly better than their counterparts in the control group. These findings therefore made it possible to still uphold the supremacy of DGSs over the traditional method of instruction where the lecture method is mostly used.

With all these findings, it can also be concluded that the use of the traditional method of instruction alone is one of the contributing factors to learner's poor performance in science and physics in particular. As such, teachers ought to begin to apply instructional strategies that are more learners centered and interactive such as the use of simulations when teaching, and depending on the availability of resources, this can be done either as a demonstration or allowing learner to explore simulations on their own with some minimal guidance from the teacher. It is important to remember that the complex nature of most topics in science and physics in particular such as Electromagnetic Induction makes it impossible to conduct such demonstrations in the laboratory. With the use of simulations however, students are helped to a greater extent to improve their ability to perform such experiments and demonstrations virtually and hence understanding of fundamental concepts being learnt. This is mainly because simulations are capable of perfectly representing and simplifying some of reality's complex processes, they can be considered to be equivalent epistemologically and ontologically to other types of cognitive models which represent reality. It is therefore high time that teachers started thinking outside the box whenever it comes to presenting such topics. Where possible and appropriate, the traditional method of instruction should be supplemented by the use of DGSs for improved performance of learners when teaching them Science and Physics in particular.

REFERENCES

1. Adams, W. K., Reid, S., Lemaster, R. L., McKagan, S. B., Perkins, K. K., Dubson, M., & Wieman, C. E. (2008). A Study of Educational Simulations Part 1—Engagement and Learning.

2. Adegoke, B. A., & Chukwunenye, N. (2013). Improving Students' Learning Outcomes In Practical Physics, Which Is Better? Computer Simulated Experiment or Hands-On Experiment?
3. Adesina, B. (2013). Improving Students' Learning Outcomes In Practical Physics, Which Is Better? Computer Simulated Experiment or Hands-On Experiment? https://doi.org/10.9790/7388-0261826
4. Ankiewicz, P., Rensburg, S., & Myburgh, C. (2001). Assessing the Attitudinal Technology Profile of South African Learners: A Pilot Study. International Journal of Technology and Design Education, 11, 93–109. https://doi.org/10.1023/A:1011210013642
5. Balliu, V. (2017). Modern Teaching Versus Traditional Teaching- Albanian Teachers Between Challenges and Choices. European Journal of Multidisciplinary Studies, 4(4), 20. https://doi.org/10.26417/ejms.v4i4.p20-26
6. Bello, S., Ibi, M. B., & Bukar, I. B. (2016). Effect of Simulation Techniques and Lecture Method on Students' Academic Performance in Mafoni Day Secondary School Maiduguri, Borno State, Nigeria. Journal of Education and Practice.
7. Campbell, D. T., Stanley, J. C., & Gage, N. L. (1963). Experimental and quasi-experimental designs for research. (pp. ix, 84). Houghton, Mifflin and Company.
8. Dervi?, D., Glamo?i?, D., Gazibegovi?-Busuladži?, A., & Meši?, V. (2018). Teaching physics with simulations: Teacher-centered versus student-centered approaches. Journal of Baltic Science Education, 17, 288–299.
9. Doolittle, J. A., & Brevik, E. C. (2014). The use of electromagnetic induction techniques in soils studies. Geoderma, 223–225, 33–45. https://doi.org/10.1016/j.geoderma.2014.01.027
10. Dori, Y. J., & Belcher, J. (2005). Learning Electromagnetism with Visualizations and Active Learning. In J. K. Gilbert (Ed.), Visualization in Science Education (pp. 187–216). Springer Netherlands. https://doi.org/10.1007/1-4020-3613-2_11
11. Falode, O. C., Usman, H., M, S., E, F., & M, S. (2015). Effectiveness Of Computer Simulation Instructional Package On Secondary School Geography Students' Achievement In Map Reading In Bida, Niger State, Nigeria.
12. Faraj, K. S., & Shadhan, A. (2020). Applications of Electromagnetic Induction. https://doi.org/10.13140/RG.2.2.17359.30882
13. Gamabri, I., & Ikusanu, E. T. (2014). Efficacy of Computer-Based Simulation on Student's Achievement in Physics Education. 2, 15–20.
14. Gamabri, I., Kawu, H., & Falode, O. C. (2018). Impact of Virtual Laboratory on the Achievement of Secondary School Chemistry Students in Homogeneous and Heterogeneous Collaborative Environments. Contemporary Educational Technology, 9, 246–263. https://doi.org/10.30935/cet.444108
15. Gambari, A. I., Obielodan, O. O., & Kawu, H. (2017). Effects of virtual laboratory on the achievement levels and gender of secondary school chemistry students in individualized and collaborative settings in Minna. http://repository.futminna.edu.ng:8080/jspui/handle/123456789/14779
16. Geelan, D., & Mukherjee, M. (2011). But does it work? Effectiveness of scientific visualisations in high school chemistry and physics instruction. In M. Ebner & T. Bastiaens (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011 (pp. 2706–2715). Association for the Advancement of Computing in Education. https://eprints.qut.edu.au/46616/
17. Gönen, S., Kocakaya, S., & Inan, C. (2006). The Effect of the Computer Assisted Teaching and 7e Model of the Constructivist Learning Methods on the Achievements and Attitudes of High School Students. Turkish Online Journal of Educational Technology – TOJET, 5(4), 82–88.
18. Haamoonga, B. C. (2017). Learner performance and teaching in public secondary schools in Zambia: A critical study [Thesis]. https://uir.unisa.ac.za/handle/10500/24461
19. Hattie, J. (2009). Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement. https://doi.org/10.4324/9780203887332
20. Isaacs, L. A. (2013). Social constructivism and collaborative learning in social networks: The case of an online masters programme in adult learning [Thesis, University of the Western Cape].

http://etd.uwc.ac.za/xmlui/handle/11394/5130

21. Isiaka, P. G. A., Shittu, A. T., Falode, O. C., & Adegunna, A. D. (2016). Effects Of Computer-Self Interactive Package (Csip) On Students' Performance, Achievement Level And Attitude Toward Mathematics At Secondary School In Nigeria. 3(1), 358–371.
22. Jimoyiannis, A., & Komis, V. (2001). Computer simulations in physics teaching and learning: A case study on students' understanding of trajectory motion. Computers & Education, 36, 183–204. https://doi.org/10.1016/S0360-1315(00)00059-2
23. Kaheru, S. J., & Kriek, J. (2016). The Effect of Computer Simulations on Acquisition of Knowledge and Cognitive Load: A Gender Perspective. African Journal of Research in Mathematics, Science and Technology Education, 20(1), 67–79. https://doi.org/10.1080/10288457.2016.1150558
24. Kapata, A. (2017). Science scholars's perceptions on rearrangement of some physics topics as a way of enhancing performance: A case of Lusaka district [Thesis, The University of Zambia]. http://dspace.unza.zm/handle/123456789/5238
25. Kirschner, P., Clark, R., & Sweller, J. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist , Discovery , Problem-Based , Experiential , and Inquiry-Based Teaching. Educational Psychologist, 41, 75–86.
26. Lamb, R., & Annetta, L. (2010). Influences of gender on computer simulation outcomes richard lamb and len annetta. Meridian, 13, 1–9.
27. Mhlongo, S., Dlamini, R., & Khoza, S. (2017). A conceptual view of ICT in a socio-constructivist classroom.
28. Moser, S., Zumbach, J., & Deibl, I. (2017). The effect of metacognitive training and prompting on learning success in simulation-based physics learning. Science Education, 101(6), 944–967. https://doi.org/10.1002/sce.21295
29. Mulauzi, F., Walubita, G., & Pumulo, J. (2020). CHAPTER FIVE Introduction of computer education in the curriculum of Zambian primary and secondary schools: Benefits and challenges (pp. 56–71).
30. Mwansa, P. M. (2022). Challenges and opportunities of the introduction of computer studies in schools: The case of selected public secondary schools in Lusaka district. [Thesis, The University of Zambia]. http://dspace.unza.zm/handle/123456789/7604
31. Nkhoma, N. (2019). An Investigation on The Challenges of Introduction of Compulsory ICT Education in Schools (Case Study on Chitambo District).
32. Oladejo, A., Nwaboku, N., Okebukola, P., & Ademola, I. (2021). Gender difference in students' performance in chemistry – can computer simulation bridge the gap? Research in Science & Technological Education, 1–20. https://doi.org/10.1080/02635143.2021.1981280
33. Perkins, K. K., Adams, W. K., Dubson, M., Finkelstein, N., Reid, S., Wieman, C. E., & LeMaster, R. (2006). PhET: Interactive Simulations for Teaching and Learning Physics. https://doi.org/10.1119/1.2150754
34. Rapp, D. N., & Kurby, C. A. (2008). The 'Ins' and 'Outs' of Learning: Internal Representations and External Visualizations. In J. K. Gilbert, M. Reiner, & M. Nakhleh (Eds.), Visualization: Theory and Practice in Science Education (pp. 29–52). Springer Netherlands. https://doi.org/10.1007/978-1-4020-5267-5_2
35. Vallverdú, J. (2014). What are Simulations? An Epistemological Approach. Procedia Technology, 13, 6–15. https://doi.org/10.1016/j.protcy.2014.02.003
36. Wieman, C. E., Adams, W. K., Loeblein, P., & Perkins, K. K. (2010). Teaching Physics Using PhET Simulations. Physics Teacher, 48(4), 225–227. https://doi.org/10.1119/1.3361987
37. Wieman, C. E., Adams, W. K., & Perkins, K. K. (2008). PhET: Simulations That Enhance Learning. Science, 322(5902), 682–683. https://doi.org/10.1126/science.1161948
38. Wu, H.-K., & Huang, Y.-L. (2007). Ninth-grade student engagement in teacher-centered and student-centered technology-enhanced learning environments. Science Education, 91(5), 727–749. https://doi.org/10.1002/sce.20216