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Teacing Balancing Of Chemical Equations Through Phet Interactive Simulations And Powerpoint Presentation Slide Show Visualisation

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ABSTRACT

This study investigates the impact of PhET interactive simulation and PowerPoint presentation slide show visualisation on learning the balancing of chemical equations to 10 th grade learners. Using a quasi-experimental reseach design, in this study, students in the experimental groups were instructed using simulation games while PowerPoint presentation slides with visualisation were used in the comparison group. Before the instructions, a pre-test was administered for balancing the chemical equations. After the instructions, a post-test was applied to determine the understanding of the learners on the topic balancing of the chemical equations. The pre- and post-test scores were analysed using descriptive and inferential statistics. Both PhET Interactive Simulation and PowerPoint presentation slide show visualisation integration were effective in teaching balancing of chemical equations. At Pre-Test both groups were almost at the same level despite the PowerPoint Presentation Slide Show Visualisation group having a high mean than the PhET Interactive Simulation. However, at post-test, the group taught using PhET interactive simulation performed better as compared to the group taught using PowerPoint presentation slide show visualisation because of the high differences in means of the two independent groups. The post-test results reviewed that the PhET Interactive Simulation had a high mean as compared to the PowerPoint Presentation Slide Show Visualisation. The PhET interactive simulation software application has already equations that are embedded in its system hence it was used to teach the balancing of chemical equations. Both the interviews, observations, and questionnaire indicated that the group taught using the PhET interactive Simulation had attained better attitudes towards learning of balancing of chemical equations as

compared to the group which was taught using PowerPoint presentation slide show visualisation.

Keywords: PhET Interactive Simulation, PowerPoint Presentation Slide Show Visualisation, Learner attitude, learner academic achivement.

1.0 INTRODUCTION

PhET is an acronym for Physics Education Technology and yet it now includes simulations about many other subjects besides Physics (phet.colorado.edu). The name PhET has been kept because it is so widely recognised. PhET Interactive Simulations can be described as imitations of systems which is a suite of research-based interactive computer simulations for teaching and learning Science, Technology, Engineering, and Mathematics (STEM) subjects. PhET simulations were founded in 2002 by Nobel laureate Carl Wieman as he had a vision on improving the way science is taught and learned(Gordon & Betty Moore, 2002). PhET Interactive Simulations are computational models of real or hypothesised situations or natural phenomena that allow users to explore the implications of manipulating or modifying parameters with them (Clarks, 2009). PhET Interactive Simulation uses techniques that mimic a real-life situation as compared to an actual situation that might be too costly, dangerous, or too time-consuming. Scientists and researchers create a similar situation but one which is less expensive, dangerous, or less time-consuming (More, 1994). The performance of learners in chemistry has been low hence the need to find better ways of improving the learners' performance. One of the reasons for poor learner performance in chemistry is a lack of practical exposure. The lack of practical exposure is a result of expensive practical apparatus and reagents which make the teachers deliver lessons theoretically. To bring a real-life situation in the chemistry class, there is a need to bring practical experience through the PhET Interactive Simulation.

Therefore, in this study, the PhET Interactive Simulation was used in the experimental group while the control group, PowerPoint presentation slide show visualisation method accompanied by teacher explanation was used. This was done to test the efficacy of PhET simulations when compared to visualisation via Powerpoint presentation. Powerpoint presentation refers to educational materials directed at both the sense of hearing and also the sense of sight. The PowerPoint presentation slides show visualisation method was used to demonstrate the process of balancing the chemical equations.

To balance a chemical equation, a learner has to change the number of molecules for any of the reactants, products, or even both to balance it. The number of molecules in a chemical equation is represented by a coefficient whereas subscripts show the number of atoms in each molecule. Coefficients can be changed to balance the

chemical equation but subscripts can not be changed. PhET simulation gives learners an opportunity for visualisation of the coefficients and subscripts in a chemical equation. The use of PHET interactive simulation enables the learners to be wholly involved in the lessons like they do when playing video games. Science education research studies carried out in recent years emphasise that constructivist learning theory provides a useful and functional framework from which to achieve the objectives of science education and provides new practices and theories to instruction (MEB, 2006). According to Schulte (1996) constructivism says that learners bring their personal experiences such as video games into the classroom and these experiences have a tremendous impact on learners' views of how the world functions. Learners come to learning situations with a variety of knowledge, feelings, and skills, and this is where learning should begin. This knowledge exists within the learner and is developed as individuals interact with their peers, teachers, and the environment. The learners can construct a full understanding or meaning by making sense of their environmental experiences and fitting their ideas into reality.
The PowerPoint presentation slide show visualisation method needs a careful mixing of media for a PowerPoint presentation to be appealing to several different learning styles and be made more interesting. The teacher is therefore encouraged to include better visual and auditory media tools into presentations although care is required because of the inevitable increase in file sizes. In this study, simulation was excluded from the PowerPoint slides used in the comparison group. This was the main reason for the extensive switch of teaching/learning materials to PowerPoint, even when the end-product was required to be an overhead projection slide. It is also easy to add a new slide whilst in a lesson if so required.

1.1 Nature of PhET interactive simulations

PhET Interactive Simulation is a non-profit open education resource project which was initiated by the University of Colorado. The project was founded by the Nobel prize winner by the name of Laureate Carl Wieman in 2002 to create and provide research-based scientific explanations. The main reason Wieman came up with the project was to improve the methods used to teach and learn science concepts. Therefore, PhET interactive simulation in this study could be explained as scientific-based computer simulations for teaching and learning various concepts in science-based subjects using game-playing environments in which learners acquire scientific knowledge and skills via scientific explorations. (Perkins, 2010). Furthermore, PhET Interactive Simulation is also defined as an interactive program that has models of either natural or artificial scientific systems or processes (Eckhardt, 2013). Actually, PhET interactive simulations enable learners to use tools that enhance active involvement and participation such that learners apply scientific concepts and test their ideas (Brunsell & Horsejsi, 2012). As result, in this study, therefore, PhET

Interactive Simulations are game-based computer programs that bring about an abstract process of any system which would allow manipulation of variables then keenly observe the outcomes as if it were in real environments with real objects. Besides, Blake & Scanlon (2007) state that among the computer-based class of software applications, Phet Interactive Simulations are the most complex as they offer a wide range of teaching and learning advantages.

A study by Loretta (2013) investigated the effect of interactivity when learning from a PhET visualization of the dynamic nature of solubility equilibria. Forty-two high-school students completed a computer lesson on solubility equilibria. All the learners completed an open questionnaire ended based on the dynamic nature of equilibrium and a conceptual test on solubility equilibria before and after the implementation. The analysis showed that the students tended to use molecular features significantly more frequently in their mental models after completing the computer lesson than before. The majority of the students found the visualization helpful. There are several computer simulation programs such as Powder Toy, Blender, OE-Cake, and Algodoo but this study is concerned specifically with PhET Interactive Simulation which can be used in both classrooms and scientific laboratories. Weiman et al.(2002), defines PhET Interactive simulations as "simulations that work through standard web browsers". Furthermore, Weiman et al. (2002) observed that PhET simulations can be used to learners from elementally to tertiary levels by using the real-world objects and scientific terms that learners can relate to their environment. As a result, learners put much effort in acquiring science concepts presented in the simulations as opposed to understand the context of the language used hence PhET Interactive Simulation is regarded as an effective learning tool. In addition, Perkins (2010) states that PhET Interactive Simulations depict the invisible and explicitly by connecting multiple representations of scientific concepts. PhET Interactive Simulation enables learners to actively participate in the learning process, by actively manipulating some variables and making observations from pre-school school to the higher learning institutions. Therefore, Phet Interactive Simulations have no restrictions concerning the age or level of education of the learner. As result, the program has great teaching strategies when well integrated into the teaching and learning of scientific concepts (Adams,2002).

Because of being highly interactive, they are named PhET Interactive Simulations as learners can manipulate some variables and make observations. As a result, PhET simulations promote inquiry methods by enabling teachers and learners to change variables in response to their questions. The learners' interaction with simulations enhances their understanding of the concepts being learned. Most of the research findings support that learners acquire skills and knowledge better when they are kept active in the construction of their knowledge within their zone of proximal development. Jia (2012) supports that learning without participating actively in the

learning process is meaningless. Adams (2010) states that PhET simulations engage learners in scientific explorations which offer dynamic feedback. Learners participate actively in creating their knowledge hence motivates learners to attain meaningful learning. The use of PhET Interactive simulations' utilisation in a classroom is in line with the theories of constructivism. One of the importance of Constructivism theory is putting learners at the centre of the learning process by allowing the learners to actively participate in the learning process. Weiman et al.(2002) support that when learners acquire scientific skills and knowledge by the use of constructivism theory through PhET Interactive Simulation, learners are motivated to acquire skills and knowledge as it develops positive attitudes towards academic achievement. This enables the learners' understanding of scientific concepts and their academic performance to be enhanced. The learners' attitude towards learning is increased which in turn improves their academic performance.

1.2 Nature of POWERPOINT presentation slide show visualization

Microsoft PowerPoint which was launched officially on 22nd May 1990 is a proprietary commercial presentation program developed by Microsoft. Microsoft PowerPoint is installed and can run on any Microsoft Windows including Apple's Mac OS X operating system. Initially, Powerpoint was called Presenter when it was designed for the Macintosh computers by Dennis Austin and Thomas of Forethought, Inc. In 1987 because of trademark problems as suggested by Robert Gaskins. When presenting a PowerPoint presentation, the presenter may choose to have slides change at preset intervals or may decide to control the flow manually. The flow of the presentation can be further customised by having slides load completely or one bullet at a time as displayed on a laptop or a projector. The slides vary such that some may contain texts, graphics, sound, and movies, which can be arranged accordingly. The PowerPoint presentation can be printed out, displayed to be viewed on a computer, or navigated through at the command of the presenter. A video projector display of slides can be used for large audiences. Mostly, webcasts are also formed from slides. Several embedded PowerPoint features are flexible in presenting professional academic work. One of these features enables it not only to create a presentation that plays music throughout the presentation but can also include sound effects for specific slides. Above all, the PowerPoint presentation can be created in such a way that it runs in a movie manner. PowerPoint enables the teachers or the learners to create a slide show with narration and a laser pointer. Microsoft PowerPoint application also can broadcast the presentation to specific users via a link and Windows Live (Microsoft.com).

In the last twenty years, educators and researchers have begun to look carefully at science education and how students learn best. Dalton (1997) states that students learn better by being involved in the lesson(learning by doing). In the learning by

doing a process, students are involved in "actively constructing knowledge concepts from a hands on experience, interpretation of results and enhanced teacher-peer interactions." Roschelle, (2000), states that learners using PowerPoint slide presentations are more likely to gain a good understanding of science concepts as its learning by doing. Most of these technological and multimedia tools are one of the ways which expose learners to this type of hands-on learning. Therefore, as researchers are beginning to understand fully the situations in which learners learn best, they have found that "the structure and resources of traditional classrooms" are often inadequate and that "technology, when it is used effectively, can bring about better teaching/learning methods that bring a better match to the learning environment." (Roschelle et al., 2000, p.79). While most of the studies of technological and multimedia tools used in the learning environment have reviewed mixed results, the best results tend to come out when the technological and multimedia tools are used in teaching natural sciences and in some cases, mathematics (Roschelle et al., 2000). Most of the present multimedia technologies enable learners to have interaction with information in new ways, alter change content, and even create their professional academic slides. Because of this interactivity, it enables its users to access a wide variety of content. Scientists normally utilise a lot of technological and media tools in their day-to-day practice, including virtual laboratories and simulations, models of scientific phenomena, and technological tools such as e-mail, video conferencing, and online collaborative knowledge bases such as wikis.

1.3 Constructivist learning theory

PHET interactive simulation and PowerPoint presentation slide show visualisation are student-centered learning methods that correlate with the constructivism learning theory where pupils are in charge of constructing their meaning actively (Almala, 2005). Therefore, constructivism learning theory has proved to contribute hugely to the student-centered learning approach where it incorporated concepts from the works of Piaget (1926), Vygotsky (1978), and Bandura (1977). Yager (1991) states that constructivism learning theory attempts to explain knowledge as being defined as a “cognitive structure of a person so that to know something is to know how to create” (Glaserfeld, 1989, p.11). This meant being able to explain concepts clearly when knowledge is acquired(Yager, 2000). Therefore, learners were supposed to actively participate and acquire necessary knowledge as compared to passive recipients. Additionally, Dewey (1972) states that education is a process of restructuring knowledge by reflecting a person's thoughts through the growth of current knowledge of learners. This meant acquiring knowledge through interaction with fellow learners and the environment. Most important is that constructivism proponents believe that pupils are active beings always seeking meaning from their

environment (Driscoll, 2000). This is in contrast with PowerPoint presentation slide show visualisation accompanied by teacher explanation which views learning as the process of direct provision of knowledge from teachers to students. However, from a constructivist perspective, learning is considered a process in which students are active in constructing their knowledge (Huang, 2006). The learners incorporate knowledge and skills through discovery and experimentation as they interact with one another and their environment (Brooks,1999). Therefore, In the constructivism learning theory, learners are encouraged to be active, socially interactive, and creative persons as they are considered constructors of knowledge, not passive receivers of knowledge (Glaserfeld, 1989). Almala (2005) suggests that students should use knowledge in many different situations and bring learning to real-life situations as possible. PhET interactive simulations project is anchored in constructivist and socio-constructivist learning theory where the design is to encourage and support the active process of constructing knowledge through interactive exchange between learners and the content rather than transmitting knowledge (Perkins,2012).

1.4 Statement of the problem

The balancing of chemical equations carries many concepts which need to be well understood by the learners. They need to learn to balance chemical equations as it's the foundation of chemistry learning. There has been a poor understanding of balancing of chemical equations which have affected other related concepts such as mole concepts in chemistry at Secondary School. The learners have been failing to correctly balance chemical equations hence affecting the correct responses to questions that require correct balanced equations. Mostly, learners fail to place correct subscripts when balancing chemical equations. This may contribute to learners from Sindh Province performing poorly in the national examinations for the past three years at Grade 12 level where it has been ranked the seond last province in the country. The poor results also include the underperformance in the field of chemistry where the academic progress has been unsatisfactory over the years. The Boards of Intermediate and Seoncdary Education have repeatedly reported a steady decline in the performance of chemistry (BISE, 2015, 2016, 2017, 2018, 2019, 2020). Additionally, the Boards of Intermediate and Seoncdary Education (2020) Examination performance report for natural sciences revealed that some candidates still exhibited a poor in-depth understanding of calculations of concentration and volume under mole concepts during practicals because of failure to correctly balance the chemical equations. This poor performance in practicals could be attributed to a lack of correct arithmetic methods in laboratory practice where the mass numbers of compounds sometimes are not well calculated. This could be made very easy had the learners learnt how to balance the chemical equations.

Furthermore, the chief examiners' reports from the Boards of Intermediate and Seoncdary Education indicate that most candidates face challenges in answering some chemistry questions such as on concepts of gases, mole concepts arising mainly from poorly balanced chemical equations(BISE, 2017). The candidates fail to accurately balance chemical equations hence failing to calculate the number of moles when it involving chemical equations. PhET simulation would therefore enable learners to actively co-operate with one another to balance the chemical equations. PhET simulation involves the use of game like computer activities hence learners would be balancing the chemical equations even using their phones instead of going to paper and pen. The PHET groups were compared to the groups that will use Powerpoint presentation slide show visualisations.

As a result, both Powerpoint presentation slides show visualisation and PhET interactive simulations therefore would enable learners to bring to a class near to reality the learning experiences which could have been learnt theoretically. This could increase the high retention rate which comes with the interactive nature of both methods. A study by Basaraba (2012) in Canada revealed that 73% of the learners who used PhET and Explore-learning simulations enjoyed using them. Similarly, a study conducted by Bozkurta and Ilika (2010) on 152 university students studying inorganic chemistry courses revealed that learning with interactive simulations has a positive effect on students' beliefs about chemistry and chemistry achievement. In general, this suggests that PhET interactive simulations have the potential to ignite student's interest in learning. Mason and Hlynka (1998) support that PowerPoint assists in structuring the appropriate concepts and the delivery of a lesson to the learners. Aiding note-taking and thus facilitating study which is another advantage of using PowerPoint. (Cook, 1998). Parks (1999) states that learners appreciated the lesson outline including graphs displayed on the screen and that the PowerPoint presentation had a positive influence on the learners. Harrison (1999) in his work also argues that PowerPoint enhances instruction and motivates students to learn. As result, this study conducted at government and privtely owned secondary schools in Sukkur, Khairpur, and Shikarpur districts, the Sindh province have accessed the impact of both Powerpoint presentation slide show visualisation and PhET interactive simulation on secondary school 10 th grade learners on learning balancing of the chemical equation.

1.5 Research questions

The purpose of the study was to explore the impact of PhET interactive simulations on the learner performance in balancing chemical equations as compared to slides used PowerPoint slide show visualisation method of learning. This study would like to answer two questions namely:

1. What are the differences in attitudes of students taught chemistry using PhET Interactive Simulations and those taught using PowerPoint presentation slide show visualisation method?
2. What are the differences in achievement of students taught chemistry using PhET Interactive Simulations and those taught using PowerPoint presentation slide show visualisation method?

2. METHODS

2.1. Research Design

This study is a quasi-experimental design. The researcher used intact classes with one wholly in treatment whilst the other class will use the PowerPoint presentation slide show visualisation. In quasi experimental design, the researcher assigned intact classes to the experimental and control groups administered a pre-test to both groups, conducted experimental treatment activities with the experimental group only, and then administers a post-test to assess the differences between the two independent groups sets (Creswell, 2008). The topic of learning of balancing of chemical equations was discussed through the PhET Interactive simulation learning method in the experimental group, and through the Powerpoint presentation slideshow slide show visualisation method in the comparison group. Each group learnt the process of balancing chemical equations. The experimental group used the PhET interactive simulation to correctly balance the chemical equations using simulation games. However, the control group used the PowerPoint presentation slide show visualisation method to correctly balance the chemical equations. Both groups conducted a maximum of six lessons of two hours each week for six weeks. The following structure shows the pre-test post-test experimental design that was used in this study.

Table 1. Pre-post test

PHET	Pre-Test(01)	Treatment (X)	Post Test O2
PPT	Pre Test(O1)	Control	Post Test O2

Where:

O1 Represented observations that were made during the pre-test measures. Both the experimental and control groups were given first the questions on balancing of chemical equations instrument as pre-test measures. The interview and the rubric were measuring the attitude and participation of the learners during the balancing of

a chemical equation. The rubric is intended to measure the attitudes and participation of learners. X represented the treatment whose impact was assessed against learners' achievement and problem-solving skills in balancing chemical equations. The experimental group was taught balancing chemical equations using PhET interactive simulation method. On the other hand, the control group was taught using the PowerPoint presentation slide show visualisation. During the intervention, the attitude would be measured by a rubric such as a learner who responds to questions, shows good body language, is respectful, and always demonstrates to ask questions would be marked as one with a good attitude. However, if a learner's questions and responses including body language were consistently not respectful and rarely demonstrates, asks questions and responses would be considered to be of a poor attitude.

O2 Represents the observations that will be made during the post-test measure. Both the experimental and control groups will be given the same questions on the balancing of chemical equations test as a post-test measure. Then comparisons will be made between pre-test and post-test between the experimental and control groups. The interview seeks to gather information on attitudes towards balancing chemical equations. During the interviews, observations such as gestures, smiles, and body language will be noted to explain whether the attitude of the learner was good or not. For instance, a learner with friendly and respectful gestures would be considered to have a good attitude because of interest but a learner who would be throwing away hands and shows as if needs to take off would be considered as one with a poor attitude.

2.2 Procedure

Balancing of chemical equations test items was administered as a pre-test to check the equivalence of the two groups, the experimental and comparison groups. However, the attitudes and participation levels of learners were measured using interviews and a rubric table. Thereafter, both the experimental group and the control group were met and briefed on PHET Interactive simulations and PowerPoint presentation slide show visualisation including the importance of working as teamwork. The comparison group will also be met to be briefed on the method they would be using which is the PowerPoint presentation slide show visualisation method and the need to co-operate with their fellow group members. The learners would be talked to about the equipment to be used during the lessons. This means that learners should know the importance of interacting with one another, respecting other members' views, sharing their views, and proper time management.

2.3 Data Collection

Two types of data were collected in this study, academic achievement data collected using test results. Qualitative data was collected using the interview and the rubric which assessed the attitudes towards the learning of balancing equations. The researcher asked a colleague to help with invigilation so that both the experimental and control groups are tested at the same time. Qualitative data was collected through pictures and observational sheets using the attitude and participation rubric to determine the attitudes and participation of the learners towards both learning activities and the teaching methods. Pictures and observational notes were made during the learning activities. The researchers alone were not able to observe all the groups of learners effectively during learning activities therefore, he asked three teachers to help with observations. The three teachers were oriented on how to make observations. For example, the rubric had where the learners' participation whether good or bad through ticking what was being observed among the learners.

2.4 Data Analysis

The data collected was analysed using Statistical Package for Social Sciences (SPSS) software by adopting descriptive and inferential statistics. Results were developed and presented in form of tables, charts, and graphs. Questions 1 and 2 were answered using a t-test at α-level 0.05. Qualitative data from interviews, pictures, and observational notes will be presented narrative. The data was inputted into SPSS software using data view and variable view. The software was able to present data in terms of means and standard deviation including in tables. However, the qualitative data was presented by narrating the observations made during the experimental period.

3. RESULTS

A normality test was conducted using the Shapiro-Wilk test of normality. The Shapiro-Wilk test examines if a variable is normally distributed in some populations. In this test, the interpretation is that when the p-value is less than 0.05, then the null hypothesis is rejected. Table 2 shows the results of the test for normality.

Table 2 Test of normality for Pre-Test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre_Test	.336	72	.000	.349	72	.000

a. Lilliefors Significance Correction

The significance of the p-value in the Shapiro-Wilk test was 0.000 which was less than 0.05, this means the null hypothesis is rejected as it's a non-normal distribution. The conclusion is that the variable is not normally distributed. Therefore, there was no significant difference between the two groups at the pre-test stage.

Table 3 shows the group statistics for both the experimental and control groups. The table has the mean and standard deviation for the group statistics including the total number of learners in each group. The total marks for the pre-test were 100%. For example, the PowerPoint group had the highest score of 60% and the lowest was 0% with most marks falling to zero scores while the PhET group had the highest score of 8% and the lowest 0% with majority marks on the average. The mean for PowerPoint presentation is 3.94, which is slightly higher than the mean for PhET interactive simulation, which was at 3.64. Even, the Mann-Witney U test would determine the significance difference between the two mean ranks of the PhET interactive simulation and the PowerPoint presentation slide show visualisation methods.

Table 3: Pre-test achievement scores

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Pre_Test	PPT	36	3.94	6.868	1.645
	PhET	36	3.64	1.885	.314

The total number of learners was seventy-two (72) where each group (N=36) had thirty-six learners. The mean for the PowerPoint presentation group was 3.94 whereas the PhET interactive simulation had a mean of 3.64. the difference between the two means was 0.3. When the means of the pretest scores of the two groups were analysed, their results showed there was no statistically significant difference between the mean scores of the PhET interactive simulation group and that of the PowerPoint presentation slide show visualisation group. The standard deviation shows how to spread the data is from the mean. It determines how far it deviates from the mean. For instance, the PowerPoint presentation group had a standard deviation of 6.868 which means the scores were spread further apart from each other, and the mean whereas the standard deviation for the PhET group was 1.885 depicting that the scores were close to each other. The implication is that both the PhET interactive simulation group and the PowerPoint presentation slide show visualisation group started at the same level. All the learners showed that there were at the same level at the pre-intervention stage. Therefore, any changes in the posttest

results can be attributed to the difference in the methods as depicted by both the group statistics and the Mann-witney U test table 4. below:

Table 4. Mann-Whitney Test

Ranks				
	Class	N	Mean Rank	Sum of Ranks
Pre_Test	PPT	36	38.15	1373.50
	PhET	36	34.85	1254.50
	Total	72		

Test Statistics	
	Pre_Test
Mann-Whitney U	588.500
Wilcoxon W	1254.500
Z	-.681
Asymp. Sig. (2-tailed)	.496

a. Grouping Variable: Class

Table 4 indicates that the mean for the PowerPoint presentation slide show visualisation group had a mean rank of 38.15 whilst the PhET interactive simulation had a mean rank of 34.85. This shows that the PowerPoint presentation slide show method performed better at the pre-test stage as compared to the group, which was to be taught using the PhET interactive Simulation method.

The above table 4 shows the Mann-Witney U test which is a non-parametric test used to compare the mean ranks of two independent groups to determine whether there is statistical evidence that the associated population means are significantly different. Under the pre-test, the null hypothesis is retained if the $p > 0.05$ and rejected when its $p < 0.05$. Therefore, the p-value for the pre-test is 0.496 which is greater than the alpha value hence the null hypothesis is retained where it would be stated as that there was no statistically significant difference between the two independent groups. At the pre-test stage, the groups were at the same level in terms of knowledge of balancing chemical equations.

3.1. Post-Test Achievement.

After implementation of the intervention, a post-test was conducted whose results are tabulated below in table 5. Table 5 below shows the normality test from Kolmogorov-Smirnov and Shapiro-Wilk. The statistical p-value at both tests is less than the alpha value of 0.05 which indicates that there was no normal distribution of variables between the two groups at the post-test stage. For example, the p-value

which is 0.016 is less than 0.05. The null hypothesis is rejected. This is which means that the conclusion is that there was non-normal distribution.

Table 5: Test of Normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Post_Test	.134	72	.003	.957	72	.016

a. Lilliefors Significance Correction

Furthermore, Table 6 shows the group statistics for the post-test stage for both groups taught using PhET interactive simulation and PowerPoint presentation slide show visualisation methods.

Table 6: Post-test Group statistics.

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Post_Test	PPT	36	76.08	10.793	1.799
	PhET	36	86.69	7.716	1.286

The mean of the group taught using PowerPoint presentation was 76.08 whereas that of the group taught using PhET interactive simulation was 86.69. The highest score for PowerPoint was 100% with the lowest being 58% whereas, for the PhET group, the highest score was 96% with the lowest being 68%. The difference between the two means was 10.61. Using PhET interactive simulation yielded better results as compared to the PowerPoint presentation slide show visualisation. Table 6 shows the Mann-Witney U test at the post-test stage.

Table 7: Mann-Whitney U Test

Ranks

	Class	N	Mean	Sum of Ranks

			Rank	
Post_Test	PPT	36	25.83	930.00
	PhET	36	47.17	1698.00
	Total	72		

Test Statistics

	Post_Test
Mann-Whitney U	264.000
Wilcoxon W	930.000
Z	-4.337
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Class

Table 7 above shows that the mean rank for the PowerPoint presentation slide show visualisation group was 25.83 while that of the PhET interactive simulation group was at 47.17. From table 7 above, it reviewed that the p-value was 0.000 which was less than the alpha value($p<0.005$) which means there was a significant difference between the mean ranks of the two groups. The null hypothesis was rejected which meant that there was a significant difference between the mean ranks of the two independent groups. Therefore, the PhET interactive simulation method yielded better results at post-test as compared to the PowerPoint presentation slide show visualisation method.

4. DISCUSSION

4.1. Summary of the results

This research was assessing the impact of PhET interactive simulation and PowerPoint presentation slide show visualisation on learning balancing of chemical equations to grade ten learners at Secondary School. The study was a quasi-experimental one where achievement and attitude towards balancing of chemical equations using either PhET interactive simulation or PowerPoint presentation slide show visualisation were assessed using pre-post achievement test, a questionnaire, interviews, and observations on the seventy-two (72) Grade ten learners sampled. The results presented in chapter four indicate that PhET interactive simulation was a better method in achieving and enhancing good attitudes and best academic achievement as compared to the PowerPoint presentation slide show visualisation method. Both methods of teaching yielded better attitudes and better academic achievement but the PhET interactive simulation was rated higher as compared to the PowerPoint presentation slide show visualisation method.

4.2. Discussion of learner's attitude towards Balancing of Chemical Equations

An attitude can be defined as a person's feelings, thoughts, and predispositions to act towards an aspect in his/her environment (Robertson, 1998). The requirement of a specific object is an important attribute of attitude, distinguishing it from personality, which reflects a person's predispositions across a range of situations (Arnold et al., 1998). In this study, therefore, the study was looking at the attitude towards learning balancing of chemical equations

4.2.1. PhET Interactive Simulation on Learners' attitude and academic achievement.

Both teaching methods brought about a significant change in attitude towards learning balancing of chemical equations. The learners had an improved attitude from pre-test to post test. For instance, PhET Interactive Simulation is also defined as an interactive program that has odels of either natural or artificial scientific systems or processes. Therefore, the method engaged learners to be working together to solve the problems which were involving balancing of chemical equations. As learners enjoy working with peers, they involved themselves in the learning process. The learners' active involvement and participation such that learners apply scientific concepts and test their ideas.

PhET interactive simulations are game based computer programs that bring about an abstract process of any system which would allow manipulation of variables then keenly observe the outcomes as if it were in real environments with real objects. The learners acquire skills and knowledge when learning is concrete. For instance, learners fail to comprehend when its abstract learning but when examples which are concrete are given, learners comprehend the concepts. This means that when PhET interactive simulations are used to depict the real environment the learners comprehend. As a result, the PhET interactive simulation is recommended for bring real learning situations to a classroom situation particularly when the concepts which are suppose to be learnt can be displayed in a classroom situation. This enables the learners to aquire necessary skills and knowledge.

The equations which the learners were balancing mostly were those which were embedded in the PhET interactive simulation software. The software has got levels where the learners can switch from low level to higher and complex chemical equations. As the learners are switching from one level to another, they increase their ability to handle the balancing of chemical equations.

As a result, both academic achievement and attitudes towards learning balancing of chemical equations are enhanced by PhET Interactive Simulation. This is because PhET Interactive Simulation is a learner centred method that is justified by constructivism learning theory. As learners are actively involved in the learning

process, they gain knowledge and skills even on trying new ways of balancing chemical equations (Almala, 2005). The learners who were taught using the PhET interactive simulation became more interested in the process of balancing the chemical equations because the learners became attached to the simulation games. Besides the learners also became motivated as each equation solved made them reach another one hence the zeal to continue working on the questions which involved the balancing of chemical equations.

Akinbobola and Ikitde(2008) state that learners exhibit a poor attitude towards a particular concept because they consider it difficult which retards their academic performance. Generally, most researchers state that whenever learners perceive a concept to be hard, their performance reduces because of their poor attitude towards that particular concept. Therefore, there was a great need in this study to arouse the interest of the learners which could, in turn, improve their attitude which would enhance their academic performance.

This study is in line with a study Mikael Winberg did in 2006 at Umea University where he looked at Simulation in university chemistry education cognitive and affective aspects. He looked at acid/bases reactions where he was investigating whether the students' attitude could improve using simulation exercise. He concluded that the students' attitude had improved greatly when using simulation exercise to study acid/bases reactions.

4.2.2. PowerPoint presentation on learners' attitude and academic achievement.

The PowerPoint presentation also enhanced an improvement on attitude and academic achievement of the learners. The powerpoint presentation slide show visualisation method promotes interest in the learning of balancing of chemical equations because of technological tools which excite them to continue working. This enhances the learners' motivation to continue working on the improved academic work. Microsoft PowerPoint presentation is an easily to use tool for most teachers with a wide range options to use when teaching various concepts especially in the field of science and particularly chemistry where different techniques are required to teach varying topics. For instance, when the learners are covering a topic on balancing of chemical equations but another concept on may be writing chemical equations comes in, a teacher can modify the slides in such a way that the concept is taught. As slides are being made,

Besides, PowerPoint enables learners to utilise similar technological equipment and multimedia tools to work like scientists by collaborating with peers. For instance, the collaboration enhances peer work among the learners which results in improved attitude towards learning balancing of chemical equations. The learners become more interested in the process of balancing chemical equations as they become

attached to the technological tools. The PowerPoint presentation slide show visualisation method motivated the learners as they watched video lessons on youtube. However, the major hindrance was poor network which made comprehension not to be fully understood hence couldn't bring very positive attitude among the learners. As observed above, the learners' attitudes towards learning balancing of chemical equations had been improving satisfactorily from pre-test activities to post-test activities for both PhET and PowerPoint presentation groups because of the change in learners' beliefs about knowledge and learning influence motivation (Windschitl, 1998), strategy selection and socio-cognitive engagement when working with peers (Hogan, Nastasi, & Pressley, 1999), and ultimately, the learning outcome.

4.3. Comparison of PhET and PowerPoint

4.3.1. Attitudes expressed in lesson observation

Both groups showed a tend where they were progressing satisfactorily as the lessons continued. As the lessons commenced in the first week, most groups scored a mark each as participation and attitude was not satisfactory. In the third session, most of the learners started participating in the lessons as one group from PhET scored a 5 which was a high score whereas most groups had improved from one score to two and three scores. This last session saw most groups scoring five which was the highest score. This meant that the learners had improved their attitude towards balancing chemical formulas. The learners had improved because their interest was aroused to work together to learn how to balance the chemical equations. Where one failed, another learner helped to get to the desirable and correct answer. The learning process involves social forces that activate behaviour.

On the lesson observation, the learners were seen co-operating with one another to solve the balancing of chemical equations. The learners also were observed helping one another to handle the computer and play the games to balance the chemical equations. The learners who were ahead and knew how to balance the chemical equations were helping those who were lagging. Therefore, the learners working in small groups was a good approach as the learners were able to teach one another. The lesson observation, therefore, reviewed that the learners had good teamwork. However, it was observed that the learners who had lessons using PhET interactive simulation had better teamwork and co-operation because of the simulation games which demanded them to co-operate with one another as compared to those in PowerPoint presentation slide show visualisation. This, therefore, indicates that the learners had actively participated and were involved wholly in the lessons.

Besides, the learners also enjoyed the balancing of chemical equations lessons that were being offered. The learners enjoyed the lessons because they were entertained and motivated by the simulation games and also it was nice to watch youtube videos which were showing how to balance chemical equations. As these teaching approaches were interesting to the learners, the learners were encouraged to continue using simulation games and watch videos hence enabling them to balance the chemical equations. As the learners seemed to be working tirelessly in groups, it was observed and confirmed by the interviewees that they enjoyed what they were doing. This was further confirmed by the learners' better performance at post-test as their enjoyment enabled them to work hard to balance the chemical equations.

The use of PhET interactive simulations and PowerPoint presentation slide show visualisation tend to be effective at assisting learners to develop satisfactory attitudes towards learning to the balance of chemical equations. Basaraba(2012) states that if PhET interactive simulations are correctly used in classes where the learners are having challenges in gaining a meaningful understanding of scientific concepts, such as balancing of chemical equations, the learners are highly likely to show significant interest in the topic which In turn improves their academic performance significantly. Therefore the use of PhET simulations can be seen as an effective solution that can improve the learners' poor performance.

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