

**EFFECTS OF COMPUTER SIMULATIONS ON THE TEACHING OF ATOMIC COMBINATIONS TO
GRADE 11 PHYSICAL SCIENCE LEARNERS**

By

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DECLARATION

I declare that

EFFECTS OF COMPUTER SIMULATIONS ON THE TEACHING OF ATOMIC COMBINATIONS TO GRADE 11 PHYSICAL SCIENCE LEARNERS

is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE

(Mrs. L. Kotoka)

DATE

ABSTRACT

This study, the effects of computer simulations on the teaching and learning of Atomic Combinations was carried out in the Tshwane North District of Gauteng Province in South Africa. The study employed a non-randomized control-group pre-test and post-test quasi-experimental design involving two grade 11 Physical Science classes; one as an experimental (52) and the other as a control group (53).

An Achievement Test consisting of 30 multiple-choice questions and a Structured Questionnaire designed for teacher and learner participants were the principal data collection tools used. The questionnaire was developed to answer research questions two and three that guided this study. The questionnaire tested how much learners and teachers were familiar with the use of computers and if there were any hindrances to computer usage. The achievement test instrument was administered as a pre-test and post-test to answer research question one.

The experimental group received computer-assisted teaching and the control group was taught using traditional teaching method (lecture) on the same topics. The intervention took two and a half weeks for each of the schools involved in the study. Analyses of scores of the two groups in post-test were compared using Statistical Package for the Social Sciences (SPSS) independent t-test version 16.0.

The results showed that $t = 0.467$, $df = 103$, $p = 0.048$ and the Sig. (2-tailed) value is 0.641. Since sig. (2-tailed) value is greater than 0.05, it can be concluded that there is no statistical significant difference between the experimental group and the control group.

KEY WORDS

- Activity Theory, Atomic Combinations, Chemistry, Computer Simulations, Information and Communication Technology, and Physical Science.

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May the Lord richly bless you all.

DEDICATION

This study is dedicated to my dear husband: Mr. J.K. Kotoka and our two lovely children,
Gladys Yayra Kotoka and Christian Delali Kotoka.

ACRONYMS

CAI	Computer Assisted Instruction
CAPS	Curriculum and Assessment Policy Statement
CAT	Computer Application Technology
CBI	Computer-Based Instruction
CD – ROM	Compact Disc - Read-only Memory
DoE	Department of Education
DOS	Disk Operating System
DVD	Digital Versatile Disc
EC	European Commission
FET	Further Education and Training
GDE	Gauteng Department of Education
GDP	Gross Domestic Product
GET	General Education and Training
ICT	Information and Communication Technology
IT	Information Technology
IUPAC	International Union of Pure and Applied Chemistry
LO	Learning Outcome
MBL	Microcomputer-Based Laboratory
NCET	National Council for Educational Technology
NCS	National Curriculum Statement
PC	Personal Computers
SPSS	Statistical Package for the Social Sciences
TI	Traditional Instruction
TV	Television
WWW	World Wide Web

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Learning Chemistry requires a particular visual understanding because many chemical concepts can be well understood by using visual representation (Habraken, 1996). In recent years there has been a call to shift from more teacher-centered learning activities to learning activities that make the learners more responsible for their own learning (Froyd & Simpson, 2010) as endorsed by Activity theory: the theoretical framework on which this research is based.

Many studies at all levels of schooling to find out learners' views about basic Chemistry concepts suggest that learners who did not obtain satisfactory understanding of scientific concepts is as a result of traditional teaching methods, such as simple lecturing. In the lecturing method, learners sit passively and do not usually engage actively in the process of learning (Morgil, Oskay, Yavuz, & Arda, 2003). In such a traditional teacher-centered classroom, the learners therefore become listeners, and the teacher gives out the facts and defines important ideas. In learner-centered teaching with the help of computers, learners are able to work together, use critical thinking and come out with alternative solutions to problems (Jaber, 1997).

According to Herman (1996) there has been interest shown in Science education reform which stresses the need for integrating computer technologies into learning and teaching. This research sought to determine the effect of using computer simulations to teach Atomic Combinations to grade 11 learners. It also sought to create an activity base classroom on one hand and on the other hand a traditional teacher-centered way of teaching Atomic Combinations. The aim of the researcher is to see the end result of the two teaching methods so that if there is a significant difference in performance after the use of the computer simulation which is a more learner-centered approach than the traditional way which is a more

teacher- centered approach, then the computer assisted teaching and learning will be recommended. But if the reverse of the above happened, then there will be no need to recommend the computer assisted teaching and learning with regards to this study.

According to Kelder (2008) an atom has a centrally charged nucleus consisting of protons and neutrons surrounded by electrons as its atomic structure. The number of electrons is equal to the number of protons: the whole entity is thus electrically neutral. Elements of an atom are listed on a periodic table of elements. Periodic table is a tabular arrangement of the elements according to their atomic numbers so that elements with similar properties are in the same column. The atomic structure and the periodic table provide vital conceptual frameworks for building a foundation for learning Chemistry. But abstract Chemistry (nonstructural materials i.e., materials of unknown, variable composition) may be seen as very challenging, since learners cannot directly observe chemical structures, including atomic structure and periodicity and relate them to processes conducted in the laboratory. In some cases too, teachers lack materials needed to effectively support learners learning of atomic structure. Thus, teachers and learners share difficulties in developing a meaningful dialogue for understanding both atomic structure and the periodic table and it is quite well documented that it is a challenging problem globally (Stieff & Wilensky, 2003; Zoller, 1990).

Some Science education researchers have shown that technology-based learning can be of help in order to address the issues of learning and understanding. Ozmen (2008) indicated in an investigation that, teaching and learning of topics in Chemistry related to chemical bonding can be improved by the use of computer-assisted teaching materials. Furthermore, it has been shown that the use of ICT in education can help generally to deepen understanding (Dede, 1998). This research however, wants to find out if computer simulations would have effect on teaching and learning with respect to Atomic Combinations.

1.2 Problem Statement

Researchers in Chemistry and Chemistry education have documented that a major difficulty with learners studying Chemistry is that of the discipline's dependency on the use of abstract concepts and models (Chalmers, 1998). Therefore this research is to determine how computer simulation affects learner's concepts learning. Access to computers in the general society is on the increase and schools are being equipped with computer laboratories. For this reason, learners can have simulation laboratories installed even on home computers to enable them perform simple experiments away from school laboratory to enhance understanding.

Simulation might not only motivate learners but provides accessible ways for learners to develop intuitive understanding of abstract Physics phenomena (Squire, Barnett, Grant, & Higginbotham, 2004). The above quote provides one with the challenge to undertake this research to find out whether simulations can provide accessible ways for learners to develop intuitive understanding of the teaching of Atomic Combinations in Chemistry.

Also, Atoms, their structure and their combinations to form molecules or compounds, is more appropriate to teach using computer simulations because it forms the basis of almost all the Chemistry aspect of the Physical Sciences. Atomic Combinations falls under a broader knowledge area of Physical Science known as Matter and Materials which runs through all the grades, from 10 -12. According to Kelder (2008) Matter and Materials focuses on the different types of materials and how matter can be classified as mixtures, substances, elements and compounds.

By Atomic Combinations, the researcher is considering the formation of molecules; compounds; bonds; electropositive and electronegative elements; molecular formulae and naming of compounds. The above concepts form the basis of Chemistry hence the selection of the topic for the research.

1.3 Purpose of the Study

The aim of the research was to study the effects of computer simulations on the teaching and learning of Atomic Combinations. The use of computer simulation is one of the approaches that have been recommended to be used by teachers to promote learners' conceptual understanding (National Research Council, 2011). It is anticipated that the use of computer simulations to teach, may bring about improvement in teaching, thereby leading to improvement of learner performance (Cigrik, and Ergul, 2009). The use of computer simulations to teach may also boost learners' interest in the Chemistry subject since children of recent times are enthused with computers. As a result, this may lead to an increase in the number of learners who wish to pursue Chemistry in school and for that matter Physical Sciences.

1.4 Significance of the study

At the end of this research, it is hoped that literature will be added to the use of Information and Communication Technology (ICT) in the teaching and learning of Science. Again it will be of much benefit to curriculum planners, Science teachers as well as learners. Most essentially, it will call for more attention towards using computer simulations to teach Atomic Combinations in Chemistry lessons. This may also encourage teachers to teach in line with the constructivist theory of learning.

1.5 Scope and Delimitation of the Study

The coverage of the topic Atomic Combinations at the level of grade 11 according to the National Curriculum Statement (NCS: 2012) runs from atoms, chemical bonds, molecular structure, electronegativity, to energy and bonding. The above topic has key concepts that include Lewis structure; Covalent bonding; Ionic bonding; Oxidation numbers; Bond energy and length; VSEPR theory; Bond polarity; Single and multiple bonds (Kelder, 2009). The researcher

concentrated mostly on Atoms, Molecules and Compounds, Bond type, Molecular formulae & IUPAC naming, Oxidation numbers, and Electronegativity. Atomic Combinations was chosen among other Chemistry topics at the level of the grade 11 Physical Science learners because it forms the basis of greater part of the Chemistry aspect of the Physical Sciences as mentioned earlier on.

The research study examined the effect of using computer simulations to teach Atomic Combinations. It focuses upon examining two schools from the Department of Education in the Gauteng Province of South Africa. This research study was limited and conducted only at Tshwane North District. The schools chosen by the researcher have computer laboratory facilities and these schools were easily accessible to the researcher. Gender or ethnicity was not being considered in this study.

1.6 Research Questions

The critical questions that this research intends to seek answers for are those listed below:

1. How do computer simulations affect the teaching of Atomic Combinations?
2. To what extent are learners and the teachers familiar with computer and its usage?
3. What factors, if any, may hinder the use of computer simulations in teaching Chemistry?

1.7 Null Hypothesis

There is no statistically significant difference in Chemistry achievement between learners taught Atomic Combinations with the use of computer simulations and others taught with traditional lecture method.

1.8 Operational Definition of Terms

Atom:	The smallest particles of matter are called atoms.
Atomic Combinations	This extends from molecular structure to chemical bonding under the knowledge area of Matter and Materials for the grade 11 NCS work schedule, 2012.
Computer:	Electronic machine operated under the control of instructions stored in its own memory that can input data, process data according to specified rules, produce output and store the results for future use.
Computer Simulations:	An attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works.
ICT:	Are technologies used for the collection, process, storage, manipulation and communication of information.
Physical Science:	In the South African system the subject Physical Science is concerned with the study of Physics and Chemistry. It investigates physical and chemical phenomena.
Traditional teaching	The teacher is the controller of the learning environment where power and responsibility are held by the teacher and he plays the role of instructor. The teacher will use the lecture method to teach the learners and will assign homework according to a specific syllabus.

1.9 Outline of Chapters

- Chapter one contained the background, problem statement, purpose, Significance of the Study, scope and delimitations, research questions, null hypothesis and summary.
- Chapter two provided the theoretical framework for the investigation done and gave a review of the literature relevant to the study.
- The third chapter described the research design, population, sample, instrumentation, validation and reliability, the methods, ethical issues, pilot study and summary.
- In the fourth chapter there were data presentations and analysis, and discussion of results,
- In chapter five, the research findings and a summary were given of the research results. Also, conclusions were drawn, and recommendations enumerated as well as limitations of the study and a suggestion stated.

1.10 Summary

In this chapter, the entire organisation of the study was presented. The background of the study, the context, the rationale, the statement of the problem, the research questions, and the aim of the study were all addressed. The hypothesis and the significance of the study were also discussed.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

It is a well-established fact that many learners find it difficult to understand chemical concepts, because Chemistry is a multifaceted discipline, requiring complex thinking and reasoning. By incorporating more visual material into a Chemistry lecture, the lecturer may succeed in restricting the overloading of the learner's short-term memory, many a time the major factor leading to misconceptions (Kemp, du Toit & Nel, 2001). The goal of this research is to investigate whether computer simulations used as a visually-supporting teaching strategy, can improve concept formation with regard to teaching and learning of Atomic Combinations.

One of the most promising means of teaching and learning Science is the internet. People's understanding of what computers can do has shifted dramatically as the size and cost of these devices has decreased while their power has increased. Before now, computers were seen as number crunching machines, but now they are tools to manipulate information, in the graphic form (Trindade, Gil, Fiolhais & Teixeira, 2003).

It is possible to acquire information through using computers and the internet in Science, especially Chemistry classes of Primary, Secondary and Higher education. The teaching tools prepared by institutions specializing in such applications could also be used in virtual media. By using such teaching tools, learners could learn the subject matter in a better way, as they are provided with a variety of knowledge, and a medium where they can observe the virtual experiments and repeat the same experiments many times if they request. As a result, it is expected that computer-assisted applications affect the learner's achievement (Morgil, Oskay, Yavuz & Arda, 2005).

A useful part of instruction in Chemistry is the performing of experiments. This can be done by demonstrations when the teacher actively carries out the experiments in front of the class or

demonstrates some materials (Bayramlıođ, 2000) or by the learners carrying out experiments in the laboratory or classroom. In this case, the role of the teacher is to guide and help the learners where necessary. Learning Chemistry requires a particular visual understanding. Many chemical concepts can better be understood by using visual representation of the phenomenon (Rutten, van Joolingen & van der Veen, 2012). In Chemistry education, different forms of graphical representations exist to support the understanding of chemical concepts for example, those under Atomic Combinations.

Scientific discovery learning is a highly self-directed and constructivist form of learning. A computer simulation is a type of computer-based environment that is well suited for discovery learning. The main task of the learner is to infer, through experimentation, characteristics of the model underlying the simulation (Ton De Jong & Van Joolingen, 2000). The development of CAI is one of the most rapidly advancing and interesting medium of instruction in recent years. Therefore, it is worthwhile to explore the effects of Computer Assisted Instruction (CAI) on learners' achievements (Bayraktar, 2002). In this research the effectiveness and efficiency of simulation environments together with how simulations may be combined with instruction to support the understanding of the concepts in Atomic Combinations was pursued.

2.2 Theoretical Framework

In the past, constructivist thoughts were not extensively appreciated because of the perception that children's play was seen as aimless and of little significance (Williams, 2006). However, Piaget (1950) disagrees with these traditional accessions. He saw play as a necessary part of the learner's cognitive development and provided scientific proof for his accession.

Nowadays, constructivist theories are significant in much of the informal learning sector. Constructivism as a pedagogy signifies the idea of intellectual independence. According to this pedagogy, the role of the teacher is to help the learners develop their own formations (Cobb, 1994). The essential core of constructivism is that learners actively construct their own

knowledge and meaning from their experiences. Learning takes place within a web of social relationships as teachers and learners interact both formally and informally.

Constructivism, the leading learning theory of the 1990s, supports Computer-Based Instruction, CBI as a means of enhancing learners' learning. Just as cognitive constructivism paved the way for the emergence of the educational theory called social constructivism (McMahon, 1997), Activity theory as a conceptual framework, with its roots in Lev Semyonovich Vygotsky's cultural-historical psychology also emerged. The founders of Activity theory were Alexei N. Leont'ev (1903-1979), and Sergei Rubinshtein (1889–1960), and others, with work starting in the 1920's. This theory supports human computer interaction.

Therefore, Activity theory is the theoretical framework on which this study is based through the use of computer simulations by the teacher to create an environment that will help the learners to reach their level of potential development which Vygotsky's (1978) work suggested can be reached with the help of a teacher or a more capable peer. Activity theory incorporates notions of understanding, history, mediation, motivation, culture and community (Leont'ev, 1981; Vygotsky, 1978). The Activity theory insists that human activity is mediated by tools in a broad sense (Kaptelinin & Nardi, 1997). Engeström (1987) extended Vygotsky's original conceptualisation for the mediated relationship between the subject and the object by introducing an expanded version of the activity triangle model that also incorporates Leont'ev's concepts.

In the model of an activity system (figure 2.1), the subject refers to the individual or group and the object (or objective) is the target of the activity within the system. Tools refer to internal or external mediating artefacts which help to achieve the outcomes of the activity. The community comprised of one or more people who share the objective with the subject. Rules regulate actions and interactions within the activity system. The division of labour shows how tasks are divided between community members and also referred to any division of power and status.

Therefore, to infuse Activity theory into the context of my study, using the classical mediational triangle, the subjects are the learners and the object (objective) is to learn about Atomic Combinations. The tools are the computer simulations and the non-ICT tools (instructions) that mediate the interactions between the subjects and the object. The learners are part of the community made up of classmates and teachers who are mediated by rules and division of labour.

An activity system is a way of visualizing the total configuration of an activity as shown below:

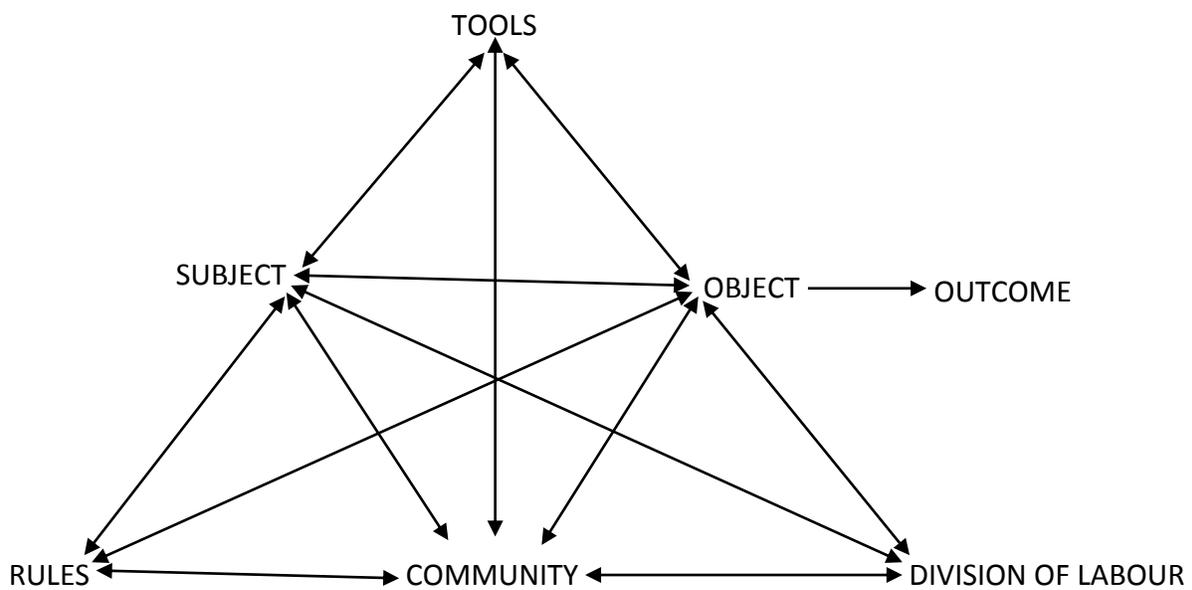


Figure 2.1: Activity System (Adapted from Engestrom's expanded Activity Theory model, 1987)

It has been observed that, computer simulations and visualization tools can serve as tools to help learners attain the level of potential development because the simulation tools enable the learners to comprehend beyond what they ordinarily have been able to comprehend (Cox, 2000). In addition, it has been observed that practical lessons in Science allow learners to share their understanding in such a way that they are able to discuss their understanding and conception in the classroom. This actually can aid general understanding and the construction of knowledge as supported by (Jimoyiannis & Komis, 2001). Therefore, Simulations can help learners to discuss in a collaborative way in the classroom. This study therefore sought to

ascertain if computer simulations can effectively affect learners learning of Atomic Combinations in Chemistry.

2.3 Chemistry Education

Chemistry is the study of matter and its interactions with other matter and energy (Kelder, 2008). Chemistry is one of the most essential subjects that permeate every scope of activity including Agriculture, Biotechnology, Engineering, Environment and Medicine. Furthermore, Chemistry has contributed enormously to improve the quality and comfort of human life in the present day world (Memije-Cruz, 2010). It is, therefore, vital that the teaching of Chemistry be done in such a fashion to lay a strong foundation on which future careers are built upon.

The understanding of key concepts in Chemistry has become easier with the advancement of Science and Technology, allowing the learning of Chemistry to be interesting and rewarding (Wiegand, 2003). Basic Chemistry is relevant hence one can choose to take a course in Chemistry and even make a career out of it. It is significant to understand Chemistry if you are studying any of the Sciences because all of the Sciences involve matter and the interactions between types of matter. Therefore, the purpose of every Chemistry teacher is to assist learners to understand scientific ideas and chemical phenomena (Barak, 2007). One way to achieve this is to have learners engage in information processing and problem solving activities that emphasize the real-world experience, and daily-life Chemistry (Dori & Hameiri, 2003).

Learners who wish to become Chemists, Doctors, Geologists, Nurses, Nutritionists, Pharmacists, and Physicists should study Chemistry. Chemistry-related jobs are plentiful and high-paying hence one might want to make a career of Chemistry. The importance of Chemistry will not be diminished over time, so it will remain a promising career path (Wieman, 2007).

However, in the South African context where this study was carried out, there is no Chemistry as a subject at the High School level. Chemistry forms part of a broader subject called Physical

Sciences and it is written as paper II of the Physical Science examinations. The Physical Science is studied at the Further Education and Training (FET) phase only which starts from grade 10-12.

2.4 Usage of ICT in Chemistry Teaching and Learning at Secondary School Level

The recent emergence of the internet as an educational tool has given rise to the quality of education experienced at many parts of the world, with many more countries still catching up with current trends in education and schooling (Fu, 2013).

Secondary education is very crucial because it is a gateway to the opportunities and benefits of economic and social development. Furthermore, globalization and the increasing demand for a more sophisticated labour force combined with the growth of knowledge-based economies gives a sense of urgency to the intensified demand for secondary education. In today's world, secondary education is being recognized as the cornerstone of educational systems in the 21st century (Gonczi, 2008). Quality Secondary education is indispensable in creating a bright future for individuals and nations alike.

In secondary education, Information and Communication Technology is relevant because its knowledge helps learners to search for the information and to organize their findings. Learners become more and more responsible for their own learning as learners develop through the school system (Otis, Grouzet, & Pelletier, 2005). Many believe that ICT needs to be better integrated into curriculums so that all schools produce computer literate, independent learners. Learners often do not perform satisfactorily in basic Chemistry concepts due to the traditional teaching methods employed by teachers. In those lecturing settings, learners are required to sit passively and become listeners (Morgil, Oskay, Yavuz, & Arda, 2003).

For Chemistry education at secondary level, more innovative pedagogical methods should be applied in teaching. Particularly, for difficult and abstract concepts, learner-centered approaches, especially those that employ modern Information and Communication Technologies should be used. In a learner-centered environment, with the assistance of

computers, learners are able to work together, use critical thinking and find alternative solutions to problems (Schroeder & Greenbowe, 2008).

According to Jang (2008) for some time now there has been interest expressed in Science education reform which stresses the need for integrating computer technologies into learning and teaching. The researcher supports the idea of using ICT in Chemistry education particularly at the secondary level of education. There is numerous literature written in line with how useful ICT has become to Science teaching and learning (Binns, Bell, & Smetana, 2010). Below is literature on some of the merits of using ICT to teach.

2.4.1 Merits of using ICT to teach

According to Cigrik, and Ergül (2009) using computers in teaching has led to an improved teaching quality which in turn leads to better learner achievement. The most significant factor in a country's success is the use of information, knowledge, and technology. Papert (1993) saw the computer as the ultimate tool for learners to use to create their own knowledge and to introduce them to the process of intellectual investigation. "Hypermedia is valuable because it encourages learners to engage in higher-order thinking, including linking and connecting sets of information. In recent years, hypermedia have been extensively adopted in education" (Ruffini, 1999, p. 419). The World Wide Web (www) is a partial hypermedia system since it supports graphical hyperlinks and links to sound and video files.

Kozma (1991) and Kozma and Clark (1993) reviewed research literature related to learning with different media, such as books, television and computer, and concluded that the computer can be a powerful tool for assisting learning because the books, television and computer can create "dynamic, symbolic representation of non-concrete, formal constructs that are frequently missing in the mental models of novices". Computers have a vital role in helping learners in learning Science and Mathematics as argued by Jaji (1991) and he also continued to state that

the way Science and Mathematics is taught can be changed by means of computers. According to Ward (1994),

“It is an increasingly powerful technology that gives teachers and learners extraordinary control over an amazing array of resources as it makes learning more vibrant, interactive, collaborative, exciting, memorable, and in the end, more satisfying. Research shows that learners who hear, see, and interact with subject matter not only remember what they learn; they also understand it, and multimedia can reach hard-to teach learners whose learning styles do not respond to traditional teaching styles” (pp. 1-2).

The above statements are mostly in line with the constructivists’ theory and the Activity theory that guided this study. And since it is believed that learning should be made exciting, memorable and satisfying, the researcher therefore, approves of the above quote and also wants to align herself to it. Musker (2000) in the editorial page of Education in Science reports: he carried out several studies comparing test results of year 10 student groups. These showed that learners using an enriched ICT Science curriculum improved their performance.

“It is very difficult to identify exactly how ICT could improve the performance of learners in tests. He believes that ICT can often put scientific information across in a different, in a more visually stimulating manner. ICT also allows learners to obtain results quicker and more easily and therefore, allows them more time to interpret them. Lastly, learners appear to be more motivated towards their lessons when ICT is used effectively and especially when it supports other successful methods of learning. He also believes ICT has a major role to play in the Science classroom of the future. It may fundamentally change the role of the teacher in the classroom. The teachers may spend a lot more time working alongside the learners instead of using “chalk and talk” at the front of the room (p. 4)”.

Skills such as drawing graphs and ability to interpret them appear to be positively influenced by computer-based experiences. Encouraging ICT impact on learner achievement has been reported by several other researchers like from a case study by Thomas and Emereole (2002)

who concluded that the combined Computer-Based Instruction (CBI) and Information Technology (IT) approach is more effective than the traditional methods alone in teaching.

Computers can be used to produce diverse simulations and visualization tools which can appeal to the learners more by explaining concepts better in that way resulting in dissatisfaction with what they already know and learners would be willing to change their previous concepts. This gives learners the opportunity of increasing their understanding of those phenomena that they cannot ordinarily see in real life according to (Khan, 2007). Trey and Khan (2008) studied the effect of computer-based analogies on learners' learning of unobservable phenomena and found that, there was significant relationship between instructional computer simulation and the achievement of learners in the content taught. The learners who were taught using the computer simulations performed better (90%) than those taught (68%) with non-analogical computer simulation. This result indicates the effectiveness of computer simulations when combined with other modes of instructional strategies such as analogies, and method of inquiry.

Although all the findings reported so far indicate a rosy picture about the use of computers in teaching, some other researchers have reported different findings. For example, Choi and Gennaro (1987) found that learners who were given the opportunity for computer-based learning of Science gained no advantage in computer-simulated experiments over learners who conducted the same experiments hands-on, though the learners were of average ability.

Arowolo (2009) reported that the analysis of the results of the post-test of his study shows that even though the two groups (experimental and control group) show no statistical significant difference in the performance from the pre-test, they also show no statistical significant difference in performance in the post-test . Also Liu, Macmillan and Timmons (1998) found that there was no significant effect of computer integration on achievement or in learner attitude toward computers after computer integration. The use of the internet for education is not without problems. Therefore, one should expect problems to be encountered in using the internet in teaching. The demerits of using ICT to teach are discussed below.

2.4.2 Demerits of using ICT to teach

It is not everything on the internet that should be seen as useful or reliable given the fact that anybody can upload what they want on it. There are some disadvantages of using ICT for teaching and learning. Teachers with no training on using Information and Communication Technologies may not know how to use them to teach their classes. Not every teacher is capable to update his or her knowledge on ICT when teaching. That is because it is not possible for some teachers to update their knowledge on technologies that they are not capable to use. The updating of knowledge becomes nearly impossible in cases in which there is no sponsor or money to pay for training courses on ICT (Suárez, 2013).

Others hold the view that learners may not do enough hands-on activities, which are vital for certain skills; or learners may have less opportunity to use oral skills and hand writing. For weaker learners, the use of ICT may be difficult because they may have problems with working independently and need more help, while enough support is not always available. Due to the fact that there are so many things posted on the internet, learners may be easily distracted and may visit unwanted websites instead of concentrating on what they have to learn. Another problem is some teachers do not see the advantages of using ICT to teach because they do not like teaching to become less structured and less subject oriented (Sorensen, nd).

The majority of teachers' first main concern is to preserve order in the classroom and to have an organized learning environment. Any proposal of embracing very innovative teaching techniques such as using ICT is therefore seen as a threat to this orderly pattern and therefore not desirable. There is a genuine fear amongst many teachers about ICT and uncertainty of its value to their learners (John, 2005). Sometimes teachers attend courses to be trained to use ICT to teach in their school. If the teacher does not get support from the school particularly the head teacher, it will be difficult for that teacher who has been trained to adopt and implement the new skills learnt (Scrimshaw, 2004). Inadequate resources is also often a difficulty for teachers who had some training to use ICT because there are insufficient ICT resources in their

school or there is no much time to review the resources and plan lessons incorporating the use of the ICT (British Educational Communications and Technology Agency, 2004).

2.5 Supporting the use of ICT in schools in South Africa

Information and Communication Technologies are central to the changes taking place throughout the world. The South African Government has seized the chance presented by the practical profits of ICTs to support teaching and learning in the twenty-first century because ICTs have the ability to improve the quality of education and training. The Department of Education White Paper on e-education (2004) stated that the number of schools with computers for teaching and learning had increased from 12.3% in 1999 to 26.5% in 2002; nevertheless, there are still more than 19 000 schools without computers for teaching and learning. The use of ICTs in Africa recorded a 20% increase in 2002, mostly due to increased usage in urban areas and countries with a higher Gross Domestic Product (GDP) per capital. However, while 72.7% of Americans currently use the internet, only 6.4% of South Africans have access to and use the internet (Van der Westhuizen, 2007).

The e-Education policy goal states that “Every South African learner in the General Education and Training (GET) and Further Education and Training (FET) bands will be ICT capable by 2013. Which simply imply that every learner is able to use ICT confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community at the end of the line. To support the above policy, Barak and Dori (2005) found that when ICT is incorporated in teaching and learning, it can enhance learners’ understanding of chemical concepts, theories, and molecular structures. Also, another study showed that ICT-enhanced learning had a positive effect on learners’ Chemistry achievements, making the learners involved in these environments actively and providing for individual learning, and visualizations of the micro and macro world (Dori et al., 2003; Stieff & Wilensky, 2003).The South African Department of Education believes that ICT “have the potential to

improve the quality of education and training” (Varughese, 2011), and this is what this research seeks to elicit.

2.6 Barriers to the use of Technology in Teaching

Although computer technologies have gained prominence since their introduction some decades ago and they have permeated every aspect of our lives from communications to financial uses, they have not been implemented in Science teaching effectively because of various factors ranging from teacher level and school-level barriers (BECTA, 2003). It is my intention to use this research to point out some of these barriers. Hence one of my research questions seeks to examine the factors, if any, that may hinder the use of ICT for instruction in Chemistry. This section therefore reviews literature on some of the barriers.

2.6.1 Teachers Resistance to Change

One of the major barriers for the cause of ICT not reaching its full potential is teacher’s attitude. Most of the literature on barriers to ICT use in schools points out that in the teaching profession, there is generally an inherent resistance to change. Veen (1993) describes this as the ‘persistence of beliefs’; teachers hold views that persist during the introduction of new innovations, and as a result educational change is a slow process, with teachers needing time to gain experience and understanding to accept the change. Dawes (2000) claims that teachers resist change in their profession just because of their personal beliefs. This attitude of teachers is identified strongly as a barrier to the use of ICT in teaching.

In theory some people may have the opinion that the teachers who had not experienced ICT throughout their learning tend to have a negative attitude towards it, as they may lack the training in that area of the curriculum. The researcher therefore, agrees with Mumtaz (2000) that there is a need for adequate and careful training so that teachers become aware of the range of uses and possible benefits of ICT.

2.6.2 Training of Teachers

There is a suggestion that there has been in the past a lack of opportunity for student teachers to make use of ICT during their initial teacher training, which directly affects their uses of ICT once qualified (Murphy and Greenwood, 1998). Simpson, Payne, Munro and Hughes (1999) suggest that a reason for this lack of opportunity is the fact that tutors in the teacher training institutions themselves have little experience of using technology in the curriculum, and are therefore unable to pass on those skills as a result. Clarke (2002) cited in BECTA ICT Research (2003) added that another barrier to student teachers' use of ICT in the classroom is the lack of ICT pedagogical training in teacher training institutions. They found that although the student teachers in their study had good ICT skills in terms of their own personal use, they were unable to transfer these skills to using ICT in the classroom. In addition, after receiving pedagogical training in ICT, the students were still not able to make full use of that training as what they had been taught did not transfer easily to what was available in the classroom during teaching practice (BECTA ICT Research, 2003).

2.6.3 Affordability

A major obstacle to the use of technology in instruction is the cost involved in purchasing the hardware, software, installing, maintenance and servicing. Arowolo (2009) reported that New Jersey spent \$10 million on classroom computers. And he argued that many education departments in African countries cannot afford such a budget on computers alone. According to the US Department of Education, over 50% of public schools had a lower rate of internet access than public schools in 1997. In addition, learners from low-income families may not have computers at home or may have computers at home with no access to the internet. Consequently, learners in low-income communities may be disadvantaged.

Another important drawback to using ICT in schools is the fact that computers are expensive. There is also a need for training related to ICT usage by all stakeholders which may equally be

expensive. According to the IT learning exchange (2001) cited in Brahmabhatt, 2012, in most schools ICT will be the single largest curriculum budget cost hence there will be little money left over for other significant costs.

2.6.4 Selecting Appropriate Technology

ICTs can enhance the quality of education in several ways, for example, by increasing learner motivation and engagement, by facilitating the acquisition of basic skills, and by enhancing teacher training. However, Fabry and Higgs (1997) reported that teachers indicated time as one of the factors preventing the integration of computers into teaching. From the many technologies available, such as simulation and modeling software, teachers find it difficult to choose the one that is appropriate for their lessons. It takes a lot of preparation time to effectively use the technology for instruction. In addition to writing and designing lesson plans, teachers may have to surf the internet to download videos or simulations and adapt them to support the curriculum objectives or visit sites to select those appropriate for classes.

The time required for making choices between available technologies and adapting this technology to their instruction is substantial. Teachers claim, there is no time available for this. Also, some of the technology resources that are accessible are not appropriate for use in the classroom. Even for those appropriate ones, since not all teachers are ICT experts, they may neglect updating their content, which can slow down the process of teaching and learning.

2.6.5 Learner Computer Literacy

The term computer literacy is used frequently in educational circles resulting in a wide variety of definitions. Computer literacy concerns the knowledge, skills and attitudes which enable a person to use computer technology to benefit them and others in relation to tasks they wish to accomplish (Newhouse, 2002). Hence the learners' computer literacy could also be an obstacle.

Computer literacy should eliminate geographic barriers for learners to be able to access knowledge resources from any location (Bhattacharya, 2007; Cross & Adam, 2007). It is believed that many learners especially those in the rural areas and disadvantaged schools do not have the necessary skills to use computers therefore the teacher needs to train them in using the computer before actually integrating or using it for lessons (McTavish, 2009).

Also, the American Association of School Librarians and the Association for Educational Communications and Technology report (AASL and AECT, 1998) posit that, the learner who is information literate accesses information efficiently and effectively, evaluates information critically and competently, and uses information accurately and creatively. Therefore, if a learner is computer literate, the learner can critically and competently research and sieve information from the internet. Then he or she can accurately and creatively answer his or her school work and school projects. Without which it will be difficult for the learner to search for information on the internet and make use of it.

2.6.6 Obsolete equipment

BECTA ICT Research (2003) reported that, the obsolescence of software and hardware is one of the obstacles to the use of technology in instruction. To acquire expensive technology and later find that it has become obsolete after a few years is disheartening. Preston, Cox and Cox (2000) found this to be a particular problem for teachers, who complained about out of date resources, and the fact that hardware became obsolete very quickly. They also note that this problem was worsened by the fact that many learners had more up to date equipment at home, and that this caused further difficulties for teachers trying to use the older technology at school.

One teacher's comment was that, "poorly specified and maintained machines mean that they are unreliable and likely to cause disruption to even the best planned lessons". In the researcher's opinion, if some schools are still using out dated software for example, office 2003 or windows 2000 while at home learners are using more up to date software like office 2010 or

windows 8. There is a chance for difficulties for both learners and teachers. As the teachers are having problem explaining concepts to learners, the learners will equally have difficulty reconciling the different features of the software they are using at home and those at school.

2.6.7 Teacher Demographics

The rate of use of technology in instruction is widely influenced by age and gender. For example, vanBraak (2001:42) reported that “males seem to be more involved in computing and have more favourable attitudes towards technology than females”. The EC report (European Commission, 2002) for example, notes that gender is an issue which determines the use of ICT by teachers, stating that 77% of male teachers use a computer off-line, compared with 66% of female teachers, and points out that the gap is wider when looking at the use of the internet; 56% of male teachers compared with 38% of females.

2.6.8 Organizational Support

Teaching using technologies brings to bear a new set of administrative demands on the teacher and the school administration (Miraesiwina, 2010). These include development and implementation of acceptable policy, training, developing new evaluation criteria as needed, and addressing parents’ concerns to a larger extent.

The failure of the organization or management to provide some form of support to the teachers such as organizing training programs, and providing an enabling environment can equally be a barrier to the use of ICT in instruction. Another barrier originates from actual breakdown of equipment, and the subsequent disruption that these can cause. If there is a lack of technical support available in a school, then it is likely that preventative technical maintenance will not be carried out regularly, resulting in a higher risk of technical breakdowns. Cuban (1999) supports this by pointing out that in the schools that cannot afford technicians, there are often, “software glitches and servers that crash, torpedoing lessons again and again”.

2.7 Integrating Technology in Chemistry teaching and learning

The growth in Information and Communications Technology (ICT) and its uses in teaching and learning Science are calling for teachers to integrate ICT into Science curriculum and instruction. This is to enhance conceptual understanding among learners, especially when visualization tools are employed (Barak & Dori, 2005). Even though ICT has been integrated in many Chemistry courses in the past few years, it is nothing more than putting a book on a screen. But it resulted in educational benefits such as promoting positive learner attitude towards Science (Hounshell & Hill, 1989). For a successful integration of technology into teaching and learning, it will require a strategic ICT training for potential teachers and teachers alike.

In spite of the problems listed above (section 2.6) and many others, some positive things have been learnt from previous experiences of different initiatives and training programs. Where schools have had the backing of the head teacher and there is a long term policy for the school to integrate ICT into teaching, the schools have seen success and gradual development in the use of ICT in different areas. Projects in which individual teachers have been given portable computers to develop their own personal ICT skills have shown that teachers then start to use them in their teaching as well (NCET, 1994). Teachers who have gone on longer courses, spread over a year have had the time to practice in between sessions back in schools and have had the time to assimilate enough expertise and knowledge to be able to continue to use them within their curriculum (Cox, Rhodes & Hall, 1988).

A number of factors which need to influence the successful integration of ICT in teaching have been identified: factors such as

- good infrastructure and adequate support;
- a clear vision, policy and strategy on what a school wants to accomplish when it implements ICT supported teaching and learning;
- a principal or school leadership that is supportive and monitors the processes of change;
- ICT becoming part of the school's culture (although not yet fully realized in all schools);
- introduction of learning and communication platforms;

- a policy on staff development (although not yet fully realised in all schools);
- support from national, regional or local authorities who have developed policies on using ICT in education and provide some schools financial means; and
- parents and local communities supporting developments.

Integration of technology into teaching may be inhibited by some crucial factors that prevent the learners and teachers from using ICT in teaching and learning. Among these are the institutional ones such as lack of proper access to ICT resources, overcrowded-classrooms, lack of technical and pedagogical support are more influential on the integration process (Nedim, 2003).

2.8 Learners Exposure to the use of Technologies

One of the questions that guided this study is 'to what extent are learners familiar with computer and its usage'. Therefore it is the researcher's idea to find literature in this regard. It is a well-known fact that children learn as they play. Majority of learners have exposure to varieties of games including television (TV) and video games. Learners are also able to operate electronic devices such as digital versatile disc (DVD) players; computers and also they manipulate their cell phones as well as calculators. Kirriemuir and McFarlane (2004) reported that computer games are presently an important part of most children's leisure times and increasingly an essential part of our culture as a whole.

Today, however, researchers, teachers and designers of learning resources are beginning to ask how this powerful new medium might be used to support children's learning. Computer games might be offering a powerful new resource to support learning in this information age hence instead of closing the door of the school against it, there should now be an increase interest towards it. About 75% of children play regularly which is beneficial, and they are learning as they play. Other authors see games (play) as inherently valuable, leading to a development of a range of skills and competences that may transfer to other social and work-related uses of

digital technologies (Williamson & Facer, 2003). Teachers and parents acknowledged that games (play) can support valuable skill development, such as:

- strategic thinking
- planning
- communication
- application of numbers
- negotiating skills
- group decision-making
- data-handling.

Games promote levels of attention and concentration that teachers, parents and policy makers wished children applied to learning. Therefore, the Department of Education can learn to use these games in order to enhance the learning process because the researcher believes that there is a relationship between games (play) and learning process. However, In order to understand the potential role of mainstream games in supporting learning, we need first to explain what 'learning' means. According to Niess, Lee and Kajder (2007) learning is perceived as how learners construct their understanding from personal experience. In the past, Jean Piaget also saw play as a necessary part of the learner's cognitive development (Piaget, 1950). The use of Information and Communication Technology (ICT) such as internet applications, CD-ROMs, video technology and various computer attachments and software programs have caused many changes in society. These changes were not just of a technical nature but more importantly of a structural nature (Reid, 2002). Many of the major institutions of our society have changed and the way we live our daily lives have been impacted. However, the impact on education may just beginning to be felt as teachers integrate this new technology into their teaching.

2.9 Background to Atomic Combinations

As the study of Chemistry begins, one of the exercises which gives a lot of fascination and challenge to the young chemists is the writing of chemical symbols, formulae and equations; for

instance, H for hydrogen atom, O for an oxygen atom and H₂O for a molecule of water. Chemical symbols, formulae and equations are very essential to the chemist. They represent information which would have needed many words. This saves time and provides easy communication of chemical knowledge. Chemical formulae are not created in the same haphazard manner that many names are chosen and given to humans. They are obtained from experiments. The tested common facts about the experiments are written down as chemical laws. Therefore, chemical formulae are based on chemical laws. A chemical formula is an expression of the results of experimental work to find the amounts of elements which combine to form a compound and shows the ratio of the number of atoms of each element present in a unit of the compound. The study of the different amounts of elements that combine to form compounds and the different amounts of substances which react to form new substances is called stoichiometry (Ameiybor & Wiredu, 1999).

Chemistry is the Science that studies matter and the changes it undergoes (Kelder, 2008). Most of the Universe consists of matter and energy. Energy is the capacity to do work. Matter has mass and occupies space. All matter is composed of basic elements that cannot be broken down to substances with different chemical or physical properties. Each substance has its own unique name and molecular formula to describe its chemical properties. Chemistry has four major areas of interest and many sub-specialties.

- Organic Chemistry - The study of the element carbon and its compounds including living matter.
- Inorganic Chemistry - The study of all other elements of non-living matter.
- Analytical Chemistry - The study of qualitative Chemistry and quantitative Chemistry. Analytical Chemistry is the analysis of compounds.
- Physical Chemistry - The quantitative aspects of the physical properties of substances and their relationship to Chemical structure and composition.

The few sub-specialties in chemistry are:

- Biochemistry - The study of biologically active substances.
- Polymer Chemistry - The Chemistry of long chained molecules.
- Solid state Chemistry - The behaviour of solids.

- Organometallic Chemistry - The Chemistry of compounds in which a metal is bonded in an organic compound.

2.9.1 Atoms and Element

The smallest particles of matter are called Atoms. An element is a substance composed of atoms with identical atomic number (Kelder, 2008). The older definition of element (*an element is a pure substance that cannot be decomposed chemically*) was made obsolete by the discovery of isotopes. Elements are substances that cannot be separated into simpler substances. Salt is made up of the elements sodium and chlorine. Water is made up of the elements hydrogen and oxygen. Chemists use symbols to represent elements. A symbol is a letter or picture used to represent something. Chemists use one or two letters to represent elements. For example, the symbol for aluminium is Al and the symbol for oxygen is O (Kelder, 2009).

2.9.2 Molecules and Compounds

The molecule is smallest subdivision of a compound that still retains the properties of that compound. The parallel definition (to that of the element above) for the molecule is: the smallest part of a compound that can enter into a chemical combination. A compound is a substance formed when two or more elements are chemically joined. Water, salt, and sugar are examples of compounds. When the elements are joined, the atoms lose their individual properties and have different properties from the elements they are composed of (Kelder, 2009). A chemical formula is used as a quick way to show the composition of compounds. Letters, numbers, and symbols are used to represent elements and the number of elements in each compound.

Molecular compounds are made of molecules.

- each molecule contains from two atoms (diatomic molecules) to thousands (biological molecules).

- each molecule has the same element composition and properties as the compound.
- its synonym is called covalent compound.
- examples are H_2O , CO_2 , $\text{C}_6\text{H}_{12}\text{O}_6$, NH_3 , CH_4 .

Ionic compounds are made of positive ions (cations) and negative ions (anions).

- cations combine with anions in just the right numbers to give an electrically neutral compound.
- metals form cations easily, and non-metals form anions, so metal/nonmetal compounds are often ionic.
- cations and anions pack into orderly arrays in solids; they become mobile when the compound melts.
- individual molecules do not normally exist.
- examples: NaCl , KBr , Na_2S , MgBr_2 .
- synonym: salts.

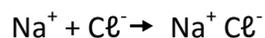
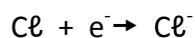
2.9.3 Bond type: Chemical bond

A chemical bond is a strong attraction between two or more atoms. Bonds hold atoms in molecules and crystals together. There are many types of chemical bonds, but all involve electrons which are either shared or transferred between the bonded atoms. A covalent bond is a very strong attraction between two or more atoms that are sharing their electrons. In structural formulas, covalent bonds are represented by a line drawn between the symbols of the bonded atoms. Covalent compound is a compound made of molecules and not ions. The atoms in the compound are bound together by shared electrons which are also called a molecular compound (De Vos, Gebretnsae, Grayson, Harris, Roodt & Schreuder, 2012). Below are examples of representations of chemical bonds in different ways, namely Lewis structure and Couper structure.

Molecule	Lewis Structure	Couper structure	Bond type
	$\text{H}\cdot + \cdot\text{H} \longrightarrow \text{H}\cdot \cdot\text{H}$	$\text{H}-\text{H}$	Single
			Double
			Triple

An ionic bond is an attraction between ions of opposite charge. Potassium bromide consists of potassium ions (K^+) ionically bonded to bromide ions (Br^-). Unlike covalent bonds, ionic bond formation involves transfer of electrons, and ionic bonding is not directional. Ionic compound is a compound made of distinguishable cations and anions, held together by electrostatic forces.

Example of ionic bonding:



2.9.4 Molecular Formulae and IUPAC Naming

Molecular formula is a notation that indicates the type and number of atoms in a molecule. The molecular formula of glucose is $\text{C}_6\text{H}_{12}\text{O}_6$, which indicates that a molecule of glucose contains 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen. International Union of Pure and Applied Chemistry (IUPAC) is an organization which sets international standards for chemical nomenclature, atomic weights, and the names of newly discovered elements. Common names of substances usually give no information about their chemical composition. Hence to describe the atomic makeup of compounds, chemists use systematic methods for

naming compounds and for writing chemical formulas (De Vos, Gebretnsae, Grayson, Harris, Roodt & Schreuder, 2012).

2.9.5 Oxidation Numbers

Oxidation numbers or oxidation states are assigned to atoms in compounds according to a set of specific rules. Oxidation numbers are useful in naming compounds, in writing formulas, and in balancing chemical equations. Compounds containing elements that have more than one oxidation state are named using the Stock system of nomenclature. Stock-system names and prefix-system names are used interchangeably for many molecular compounds. In many molecular compounds, oxidation numbers of each element in the compound may be used to determine the compound's simplest chemical formula (Kelder, 2009). By knowing oxidation numbers, we can name compounds without knowing whether they are ionic or molecular. Example: Calculate the oxidation numbers of Mn in KMnO_4 .

$$\begin{array}{r} \text{K} \quad \text{Mn} \quad \text{O}_4 \\ \\ +1 \quad + \quad \text{Mn} \quad + \quad (4 \times -2) = 0 \\ \\ \text{thus:} \quad \text{Mn} \quad = +7 \end{array}$$

2.9.6 Electronegativity

Electronegativity is the ability of an atom to attract or pull electrons to itself when it is in a molecule (De Vos, Gebretnsae, Grayson, Harris, Roodt and Schreuder, 2012). An atom of a molecule which tends to attract more electrons to it is described as a more electronegative atom. The main factor that influences the value of electronegativity is the atomic radius of the atom. Usually it is said that the smaller the atomic radius, the higher the electronegativity. The

most electronegative element is fluorine (F) with a value of 4. Electronegativity predicts type of bond formed between atoms.

2.10 Summary

Relevant literature concerning this research has been reviewed in this chapter. The theoretical framework for this study is the Activity theory and constructivist theory which promote more learner-centered lessons than teacher-centered, and how ICT can serve as a useful tool in instruction. Some of the literature reviewed indicated improvement in learner performance in some Science topics after using computer simulations to teach (see section 2.4.1). Other literature showed that computer simulations do not always improve performance of learners (see section 2.4.1). However, the review of relevant literature did not bring to the fore any literature on the use of computer simulations to teach Atomic Combinations, especially in the South Africa setting. It is this gap that this research seeks to fill. In this regard, this research made use of simulations to teach Atomic Combinations. The next chapter therefore, talks about the methodology and the research design of the study.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The study made use of a Non-Randomized Quasi-Experimental pre-test and post-test control group design where learners' in existing grade 11 Physical Science classes were used. Below is the flow chart of the design.

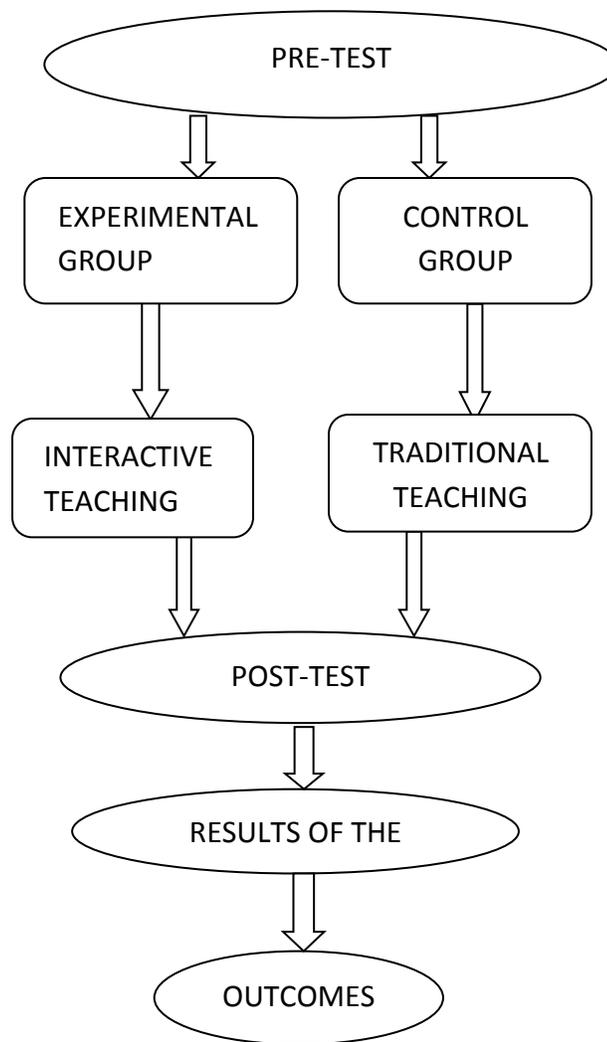


Figure 3.1: *Flow Chart of Research Design.*

3.2 Population of the Study

The population of this study was all grade 11 learners offering Physical Sciences as well as their teachers who were chosen from two high schools in the Tshwane North District in Gauteng province of South Africa. One class was referred to as the control group and the other experimental group. The experimental group was subjected to computer simulations used to teach the Atomic Combinations, while the control group was exposed to traditional method of teaching (chalk-talk).

3.3 Sample and Sampling Technique

The sample of the study was selected through the application of random procedures. The sample of the learners who took part in the study was a total of 105 grade 11 Physical Science learners. One of the two classes of the two different High Schools that were chosen at random to be an experimental group was made up of 52 learners and the other, the control group was made up of 53 learners. The instruments in the study were an achievement test which served both as the pre-test and as post-test and a structured questionnaire with lines provided for comments where necessary. The spaces provided for comments are to give the respondents opportunity to add information not tapped by the close-ended items.

A pre-test was administered to the two groups. The pre-test was used to ascertain the learners' prior knowledge in Atomic Combinations before the intervention. After the intervention, the learners wrote a post-test to assess the effect of the intervention and to measure learners' performance after the lessons. Lastly, both learners and their teachers completed a questionnaire drawn to solicit responses to help the researcher answer research questions two and three that guided this study.

3.4 Instruments

3.4.1 Development of Instruments

The first instrument used was an achievement test which contained thirty items (appendix B) of multiple-choice questions type. The test was developed around the learning areas under the topic Atomic Combinations (Atoms, Molecules and Compounds, Bond type, Molecular formulae & IUPAC naming, Oxidation numbers, and Electronegativity). The test items were selected from the grade 11 textbooks popular with teachers and learners and past examination questions.

In addition to the test, a structured questionnaire was developed to be used to seek answers to research questions two and three of the study (appendix C). The structured questionnaire that was used for this study was adapted from Kotoka (2012) and slightly modified to suite this work. Some sections of the questionnaire were developed differently for learners and teachers. The questionnaire for both learners and teachers had three sections namely section A, B and C. Section A sought personal information about the learners and the teachers. While sections B and C were based on research questions two and three.

The questions in sections B and C were modified into six-point Likert scale type questionnaire with spaces provided for comments where necessary in order to get the respondents' opinions as well. The six-point Likert scale type was chosen because the even number scaling system eliminates the possibility of respondents opting for a mid-point position and to have respondents commit to either the positive or negative end of the scale (Cohen, Manion, & Morrison, 2007).

3.4.2 Validity and Reliability of Instrument

3.4.2.1 Validation

Content validation was carried out by six chosen experts. It was to ensure that the instruments were well structured, well planned and well organized based on the content of the learning area of the study. The test items were strictly based on Atoms, Molecules and Compounds,

Molecular formulae and IUPAC naming as the content of the grade 11 Physical Science syllabus demands. The instruments were first critiqued by the supervisor and then by two other senior Science teachers, two Physical Science cluster leaders and a Physical Science facilitator in the Tshwane North District (Gauteng) to ensure readability and comprehension.

Then, the test instrument was administered to 92 learners by their teachers in a different school as a pilot study. This pilot group is different from the sample for the study. The pilot school was chosen based on the fact that they were also Physical Science learners in grade 11. At the time of the study they had treated Atomic Combinations. The school has a similar background as those used in the study. The aim of the researcher was to see if the research instruments were comprehensive, readable, answerable and unambiguous. Again, the test instruments were re-administered to the classes later in about two weeks to predict how well individual learners performed to ensure predictive validity. These amongst others ensured that the data collected is valid.

Also, for appropriate time scale, the whole data collection period took five weeks for both control and experimental group. For each group, two and a half weeks were used for the data collection; pre-test; intervention; post-test; and answering of questionnaires, so that the learners will be prepared for the exercise psychologically. There were adequate numbers of test papers, and questionnaires, for each individual learner as well as pencils and erasers. To ensure that all learners in the class returned their scripts as well as pencils and erasers, a class list was used each time when learners collected and returned the test papers and questionnaires.

3.4.2.2 *Reliability*

In addressing reliability of the study, a pilot group was chosen as indicated above. The instruments were administered to the group for testing. The test instrument was re-ordered and administered to the same class later in two weeks. Then the two sets of scores were correlated and the results evaluated using the Kuder-Richardson-21 (KR-21) formula. The marks obtained (appendix D) were used to calculate the coefficient of reliability using the (KR-21)

formula. The first marks obtained yielded a KR-21 coefficient of reliability of 0.97 while the second time the pilot sample took the test, there was a slight decline in the marks obtained as the result, and the calculated coefficient of reliability was 0.94 (appendix E). The interpretation of these coefficients of reliability follows from the fact that reliability is the degree to which a test consistently measures whatever it measures (Gay & Airasian, 2003). A high coefficient that which is close to 1.0 indicates high reliability. It can be concluded therefore that there is consistency when comparing the two coefficients of 0.97 and 0.94 which are very close (appendix E). This helped to check for the consistency of the response from the learners.

3.5 Method of Data Collection

The pre-tests administered to the two groups were marked and the marks recorded. The lessons were organized by the researcher. For the control group, the lessons were organized by the researcher and taught by the researcher using normal classroom teacher-centered method on the topic Atomic Combinations. Also, for the experimental group, normal teaching method and computer simulations were used to teach the same areas of Atomic Combinations. The lessons were taught by the researcher. After the delivery of the lessons to the two groups by the researcher, the pre-test was reordered and administered as a post-test. This was to ensure that the level of difficulty for the post-test and the pre-test are maintained, and the tests being the same for the two groups.

The purpose of the post-test is to evaluate the achievements of the two groups after learning about Atomic Combinations. The post-test was also marked for the two groups and the marks recorded (appendix F). Then the teachers and learners also answered a structured questionnaire in order to answer the research questions two and three. To deal with the issue of biasness, the researcher worked with one school at a time. The problem of contamination does not arise here because the two schools chosen are not in close proximity. The researcher thought it wise to teach the control group first before the experimental group. The introductory meetings with the learners, the administering of the pre-tests, the lesson

presentations (four sections) and the writing of the post-tests as well as responding to the questionnaires took two and a half weeks for each of the schools involved in the study as indicated earlier.

3.6 Method of Data Analysis

The data from this study is quantitative and was analyzed quantitatively due to the fact that the research is based on the collection and analysis of numerical data which were obtained using tests. Also, existing classes were randomly assigned to either group (control and treatment) as indicated under sampling. Marks for the pre-tests and the post-tests for the two groups were analyzed using statistical techniques such as, mean, standard deviation and t-test to make inferences. The reason for choosing a t-test is because only the mean scores from the pre-test and or post-test for the two groups, control and experimental were compared to see if there was any statistical significant difference at a selected probability level of 0.05 between the two groups. The researcher did not intend to compare both pre-tests and post-tests concurrently of the two groups. Nevertheless, the mean scores of the pre-tests and post-tests of the two groups were individually compared to ascertain their knowledge gains after the lessons.

The results from the questionnaire were also analyzed and discussed based on the various responses of the teachers and the learners. To analyze the teachers and the learners' questionnaires, tables were used to highlight findings from the data collected and narrative explanations were used for the analysis. Quotations and scanned copies of learners and teachers responses in the questionnaire were used to illustrate and support findings.

3.7 Ethical Issues

The researcher applied for ethical clearance and received approval from the Ethics Review Committee of the University of South Africa according to the university's requirements. Also, the researcher submitted an introductory letter prepared by her supervisor to the Gauteng

Department of Education (GDE) and applied for permission to conduct a study in two schools in the Tshwane North District of the province and received an approval. The introductory letter, the ethics clearance and GDE research approval letter are found in Appendix A. The researcher issued consent letters to the principals of the schools involved, teachers, parents and learners who participated in the study.

Respondents were not forced into completing a questionnaire but were simply encouraged; but the decision whether to be involved and when to withdraw from the research was entirely theirs (Cohen, Marion & Morrison, 2007).

Therefore the involvement of the classes chosen was based on the following among others:

- Their informed consent.
- Their rights to withdraw at any stage of the program.
- Their right not to complete particular item(s) in the questionnaire.
- The guarantees that the research will not harm them.
- The guarantees of confidentiality in the research.
- The avoidance of bias and assurance of validity and reliability in the questionnaire.
- Not committing to an act which might diminish their self-respect.
- Not being exposed to questions which may be experienced as stressful or upsetting.

3.8 Pilot Study

A pilot study was conducted to test the various instruments that were used in this research in order to detect any likely mistakes or oversights, and if questions were clear to the respondents and to determine the reliability as stipulated under instrumentation. Problems that arose during the piloting were sorted out by reframing any unclear questions, omitting some questions and merging questions that seemed similar. All the two instruments were found appropriate to obtain responses that would assist answer the questions of the study.

3.9 Summary

The chapter described the methodology of the entire study. How the instruments were developed, as well as how data was collected and analyzed. It also dealt with validity, reliability and ethical issues.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Overview

In this chapter, data is presented, and analyzed to arrive at results and then the results discussed. The analysis is to help answer the three research questions which read as follows;

- How do computer simulations affect the teaching of Atomic Combinations?
- To what extent are learners and teachers familiar with Computer and its usage?
- What factors, if any, may hinder the use of computer simulations in teaching Chemistry?

4.2 Analysis of Test Scores

The results from both the pre-test and the post-test were analyzed using statistical tools as already indicated in section 3.6 above. The scores for the two tests of the two groups can be found in appendix F. The scores analyzed are the final marks of the two groups as they performed in each of the tests. A Statistical Package for the Social Sciences (SPSS) version 16.0 was used to compute the mean, the standard deviation and the t-test that helped the researcher to determine the level of significance of the different performance of the learners in the experimental and control groups. The researcher further used the mean scores of the two tests within each group in order to be able to compare the performance of the learners from pre-test to the post-test.

4.2.1 Analysis of the Pre-test for Control & Experimental Groups

A pre-test was conducted before the treatment to establish whether or not the two groups were of the same ability or are comparable in terms of the topic Atomic Combinations before

the treatment started. The scores of these tests were also analyzed and the result (means) is indicated in table 4.1. A t-test was calculated as shown in table 4.2 below. In this analysis, t -statistics = 0.831, df = 103, F = 0.048, Sig (2-tailed) = 0.408. Even though, the mean of the control group (35.13) is slightly higher than that of the experimental group (34.04) by 1.09 as indicated in table 4.1, there is no statistical significant difference in the achievement level of the two groups in the pre-test. This confirmed the equivalence of the two groups before the treatment. Therefore it is evident that before the treatment the two groups were at the same level of achievement in the topic Atomic Combinations.

4.2.2 Analysis of the Post-test for Control & Experimental Groups

The post-test scores for the two groups (experimental and control group) were analyzed and the result (means) is also presented in tables 4.1 and 4.2 below. From table 4.2, t -statistics = 0.467, df = 103, F = 0.874 and Sig (2-tailed) = 0.641. The interpretation of this result is that if the Sig (2-tailed) value is greater than 0.05, it can be concluded that there is no statistically significant difference between two groups and if the Sig (2-tailed) value is less than or equal to 0.05, it can be concluded that there is a statistically significant difference between two groups. Since the Sig (2-tailed) = 0.641, and the t -statistics = 0.467, which are both greater than 0.05, there is no statistically significant difference between the post-test scores of the experimental group and the control group.

This analysis indicated that computer simulations did not significantly influence performance of learners in the experimental group in the said topic. Leading to the acceptance of the null hypothesis which said there is no statistical significant effect of the use of computer simulations on the teaching of Atomic Combinations in Chemistry.

Nevertheless, the experimental group achieved slightly more with a mean mark of 39.58 compared to the control group who had a mean mark of 38.98 as shown in table 4.1 below.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Experimental Group	52	34.04	6.526	.905
	Control Group	53	35.13	6.945	.954
Posttest	Experimental Group	52	39.58	6.204	.860
	Control Group	53	38.98	6.837	.939

Table 4.1: Mean scores of pre-test & post-test of the Control & Experimental groups.

Table 4.2 below shows statistical analysis of Independent Samples t-test for the control group and the experimental group that took part in this study.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Pretest	Equal variances assumed	0.048	0.827	-0.831	103	0.408	-1.094	1.316
	Equal variances not assumed			-0.832	102.81	0.408	-1.094	1.315
Posttest	Equal variances assumed	0.874	0.352	0.467	103	0.641	0.596	1.275
	Equal variances not assumed			0.468	102.38	0.641	0.596	1.274

Table 4.2: Independent Samples t-Test for the Control & Experimental Groups.

4.2.3 Intra-group Performance Analysis Based on Mean Scores

Looking at the mean scores of the control group, it can be seen that their performance had improved from 35.13 in the pre-test to 38.98 in the post-test. The experimental group mean scores improved from 34.04 in the pre-test to 39.58 in the post-test (see table 1). Even though the t-test analysis indicated no statistically significance difference, the experimental group made an improvement of 5.54 compared to the control group that improved by 3.85 in their mean scores. On the whole the experimental group can be said to have achieved better after the intervention. Furthermore, learners in the experimental group were much more motivated and showed enthusiasm and interest when taught using computer simulations. This is in line with Sanger (2000) who also reported in a study that computer simulations assist in improving conceptual understanding of Science.

4.3 Analyzing the Responses to the Questionnaires

The questionnaire was meant to assess the responses of Physical Science grade 11 learners and their teachers from two different schools. There were seventeen statements on a six-point Likert scale learners' questionnaire requiring learners to indicate their opinions about the use of Information and Communication Technology, in the teaching and learning of Chemistry. Also, there were eighteen statements for the teachers' questionnaire. The questionnaire was administered to 105 learners and their two teachers in the two different schools.

The questionnaire for both teachers and learners consisted of three sections. The first section required learners and teachers to provide their demographic background. The second section of the learners' questionnaire consisted of ten statements on a six-point Likert scale requiring learners to indicate the extent to which they were familiar with computer and its usage. But there were seven statements for the teachers in the second section (see Appendix C) in this regard. The third section contained seven statements for the learners and eleven for teachers on 'Factors, if any that hinder the use of computer simulations in teaching' (Appendix C). Scores

of learners were obtained by summing up the number of responses under each rating on the scale using the keys 1,2,3,4, 5 and 6 representing strongly disagree (S_tD), disagree (D), slightly disagree (S_lD), slightly agree (S_lA), agree (A), and strongly agree (S_tA), respectively. The six-point Likert scale was further categorised into only “Agree” and “Disagree” for easy analysis.

4.3.1 Section A: Demographic Background

The total number of learners who completed and returned their questionnaire were 101; this represents 96.2% of the total group. All the 101 learners that completed the questionnaire were in a day school not boarding. Of these learners, 26.7% were male (n=27) and 73.3% female (n=74) with their average age at seventeen years old. The two teachers were both males and were over 35 years old. The teacher of the experimental group has BSc. (Hons) Physics qualification while the teacher of the control group holds B.Ed (Hons) Science.

4.3.2 Questionnaire Analysis: Experimental Group

4.3.2.1 Section B: The extent to which the experimental learners are familiar with Computer and its usage

The analysis of the learners’ responses to section B of the learners’ questionnaires and the six-point Likert scale which has been categorised again into “Agree” and “Disagree” and their percentages calculated are shown in table 4.3 below. As the data collected from section B were analyzed, the results showed that out of ten statements in the questionnaire (appendix C), learners of the experimental group disagreed with only statements four and five. These statements read as follow:

- I make use of internet at school.
- I make use of internet at home.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S ₁ D	D	S ₁ D	S ₁ A	A	S ₁ A	Agreed	%	Disagreed	%
One	0	1	2	11	18	18	47	94	3	6
Two	5	5	1	12	15	12	39	78	11	22
Three	8	2	3	8	18	11	37	74	13	26
Four	18	5	4	7	10	6	23	46	27	54
Five	13	7	6	7	11	6	24	48	26	52
Six	5	1	2	6	11	25	42	84	8	16
Seven	2	1	2	3	14	28	45	90	5	10
Eight	2	1	2	6	14	25	45	90	5	10
Nine	5	2	2	8	15	18	41	82	9	18
Ten	12	7	4	11	10	6	27	54	23	46

Table 4.3: The Experimental school Learners' responses to section B of learners' questionnaire.

The results revealed that 54% and 52% of learners disagreed that they make use of internet at school and at home respectively (table 4.3). The learners do not make use of internet at school (statement four) because according to the learners, they are mostly not allowed. The 46%, who responded in favour of statement four, reported that they only make use of internet at school when it is needed to complete an assignment but with a teacher's permission. Also, the learners use the internet for research, especially in Computer Application Technology (CAT) or Information Technology (IT) classes.

As indicated in chapter three, section 3.3 and 3.4, spaces were provided on the questionnaire for respondents' comments where necessary, hence some learners wrote the reasons why they disagreed with statements four and five. This was also confirmed during informal interviews with learners after the intervention. Below are few scanned exhibits of the reasons why learners are not making use of internet at school and at home.

4. I make use of internet at school. [2]
 When given permission

4. I make use of internet at school. [3]
 We use internet in computer lab only when needed, ~~and~~ either than that we don't.

4. I make use of internet at school.

To do task or search for information

5. I make use of internet at home.

We don't have internet.

5. I make use of internet at home.

When granted permission

5. I make use of internet at home.

There's no internet modem or anything that connects to the internet

5. I make use of internet at home.

I don't have internet at home. Only on my phone.

The learners agreed to the remaining eight statements which were in favour of making use of ICT and using ICT to learn (appendix C). In terms of percentages, 94% of learners agreed to statement one, which states that “my Physical Science teacher uses computer simulations to teach”. While 90% goes with statements seven and eight each, which also say, “my school has a computer laboratory, and my school’s computer laboratory is connected to the internet”. Statement ten had the least percentage (54%) agreement in favour of “I make use of the ICT resources like internet cafes in my community” (table 4.3).

The fact that learners agreed that they have been using computers at school, at home and make use of the ICT resources like internet cafes in their communities showed that these learners are conversant with computers. Also, their Physical Science teacher uses computer simulations to teach them.

The response of the learners to all statements in exception of four and five in section B showed that learners are familiar with computer and its usage. Therefore, in answering research question two, the researcher can confidently say learners are mostly familiar with computer

and its usage to an extent. Other scanned exhibits of learners comments from the learners' questionnaire to support claims are shown below.

1. My teacher uses computer and computer simulations to teach. [6]
He uses slide shows to demonstrate most of the work
2. I have been using computers at school. [5]
I use it to do my work and it granted permission to look for info in the internet
3. I have been using computers at home. [4]
To do my work and extra materials
4. I make use of internet at school. [2]
When given permission
5. I make use of internet at home. [4]
I use the internet only when I have the money to buy a data bundle.

4.3.2.2 Section B: The extent to which the experimental school teacher is familiar with Computer and its usage

Results from the experimental school teachers' questionnaire on section B, has been summarized in table 4.4 below.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _t D	D	S _i D	S _i A	A	S _t A	Agreed	%	Disagreed	%
One						1	1	100	-	-
Two						1	1	100	-	-
Three						1	1	100	-	-
Four						1	1	100	-	-
Five						1	1	100	-	-
Six						1	1	100	-	-
seven					1		1	100	-	-

Table 4.4: The Experimental school Teacher's responses to section B of the questionnaire.

The teachers' questionnaire is not entirely the same as that of the learners (appendix C). The differences are due to the number of statements in each section and the wording of the statements. For example, there are seven statements in section C of learners' questionnaire whereas there are eleven in the teachers' questionnaire.

The table above presents the experimental school teacher's responses to section B of the teachers' questionnaire. It shows the total percentage responses for statements agreed to and statements disagreed with by the teacher respondent.

The outcomes from table 4.4 showed that the experimental school teacher unlike his learners, agreed with all seven statements on the teachers' questionnaire. The following are the seven statements;

- I have been using computers at home, and in school to teach.
- I use computer simulations to teach Physical Science.
- I make use of the internet.
- My school has a computer laboratory.
- My school's computer laboratory is connected to the internet.
- There are ICT resources (e.g. internet cafes) available in my community.
- I make use of the ICT resources like internet cafes in the community.

On a whole, to answer research question two based on the teachers' questionnaire, it is obvious from the analysis that the teacher is familiar with computer and its usage to a larger extent. Below are scanned exhibits of some of the teacher's comment on making use of computer and computer simulations to teach his learners.

1. I have been using computers at home. 6
I have my personal laptop at home that I use almost daily.
2. I use computer simulations to teach. 6
I use my laptop computer to teach at school. using power point and simulations

3. I make use of internet. 6

I make use of the internet always at home and sometimes at school.

4.3.2.3 Section C: Factors, if any that hinders the use of Computer Simulations in teaching (Learners' responses)

Below is table 4.5 that shows the results of the experimental learners' responses to section C from the learners' questionnaires as well as the six-point Likert scale questionnaire for section C that has also been further re-grouped into "Agree" and "Disagree" and their percentages calculated for each response.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _t D	D	S _i D	S _i A	A	S _t A	Agreed	%	Disagreed	%
One	12	10	12	11	4	1	16	32	34	68
Two	7	7	9	15	10	2	27	54	23	46
Three	22	8	8	5	3	4	12	24	38	76
Four	25	11	7	4	2	1	7	14	43	86
Five	26	12	5	4	2	1	7	14	43	86
Six	6	6	3	10	14	11	35	70	15	30
Seven	4	2	2	7	15	20	42	84	8	16

Table 4.5: The Experimental school Learners' responses to section C of the questionnaire.

There are seven statements under section C of the learners' questionnaire. Learners disagreed with statements one, three, four and five. The results showed 68%, and 76% of learners disagreeing with statements one and three, while 86% disagreed with four and five each. Statements one, three, four and five are as listed below.

- All the schools in my district have the ICT infrastructure.
- I find it time consuming to use computer simulations in learning Chemistry.
- I get confused during the learning of Chemistry when my teacher uses ICT.
- I get confused during learning of Chemistry when using ICT.

But 70% of learners agreed with statement six that they need assistance to be able to use computer simulations on their own. Apart from statement six, 54% learners agreed with

statement two to say they can get access to computer simulation software programmes and 84% of learners, agreed to statement seven saying computers available in their schools are enough for all learners in the classroom. So statements two and seven are ruled out as factors that may affect the use of ICT to teach. Statements three, four and five may as well not be factors hindering the use of ICT because from the responses, learners do not find it time consuming to use ICT in learning Chemistry, or get confused during learning of Chemistry when using ICT and when their teachers use ICT to teach. It surfaced from the responses that time, confusion, accessibility to software and availability of computers may not be factors hindering ICT usage. The statement which poses a problem is statements one where 68% of learners disagreed that all the schools in their district have the ICT infrastructure. Learners added that they cannot learn Chemistry with computer simulations on their own; they may need help from their teachers. And 70% of the learners agreed to statement six. That makes statement one and six an issue. Below are statements one and six;

- All the schools in my district have the ICT infrastructure.
- I cannot learn Chemistry with computer simulations on my own; I need help from my teacher.

In summary, from the study, it can be pointed out that inadequate ICT infrastructure and the teacher guiding or helping learners to learn with simulations may be the factors hindering using ICT to teach. To answer research question three, it can be resolved that statements one and six are the factors that may hinder the use of ICT to teach according to the learners. Scanned exhibits of some learners' comments concerning statements one and six are shown below.

1. All schools in my district have the ICT infrastructure.
 Not all schools in my district have
ICT infrastructure.

1. All schools in my district have the ICT infrastructure.
 Not all the school only few.

1. All schools in my district have the ICT infrastructure.
 Not every school has ICT infrastructure

6. I cannot learn Chemistry with computer simulations on my own; I need help from my teacher.
 Because I can't do some
computer.

6. I cannot learn Chemistry with computer simulations on my own; I need help from my teacher.
 They're not simplified and teachers do that for you.

4.3.2.4 Section C: Factors, if any that hinders the use of Computer Simulations in teaching (Teachers' responses)

Out of the eleven statements in section C of the teachers' questionnaire, the teacher of the experimental group agreed with seven of the statements as can be seen in table 4.6 below. Because the teacher agreed with these seven statements, they are eliminated as factors that may hinder the use of ICT in teaching Chemistry. Below are the seven statements that the teacher agreed with.

- The curriculum support ICT usage in teaching Chemistry.
- The time table of the school permits the use of ICT in teaching Chemistry.
- The content of the Physical Science syllabus allow the use of ICT in teaching.
- Schools and teachers can get access to computer simulation software programmes that are compatible with the South African syllabus.

- Learners can get access to computer simulation software programmes that are compatible with the South African syllabus.
- Learners cannot learn Chemistry with computer simulations on their own; they need help from the teacher.
- Computers available in my school are enough for all learners in my classroom.

Below is table 4.6 which shows the experimental school teacher's responses to section C of the questionnaire.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _t D	D	S _i D	S _i A	A	S _t A	Agreed	%	Disagreed	%
One	1						-	-	1	100
Two	1						-	-	1	100
Three						1	1	100	-	-
Four						1	1	100	-	-
Five				1			1	100	-	-
Six					1		1	100	-	-
Seven					1		1	100	-	-
Eight		1					-	-	1	100
Nine		1					-	-	1	100
Ten					1		1	100	-	-
Eleven						1	1	100	-	-

Table 4.6: The Experimental school Teachers' responses to section C of the questionnaire.

The respondent disagreed with statements one, two, eight, and nine, but the only statements among these which may be considered as factors that may hinder the use of ICT to teach are statements one and two. This is because of the way these statements are structured. Below are statements one and two which are being considered as factors:

- All schools have the ICT infrastructure in my district.
- Government is ready to make ICT infrastructure available to schools.

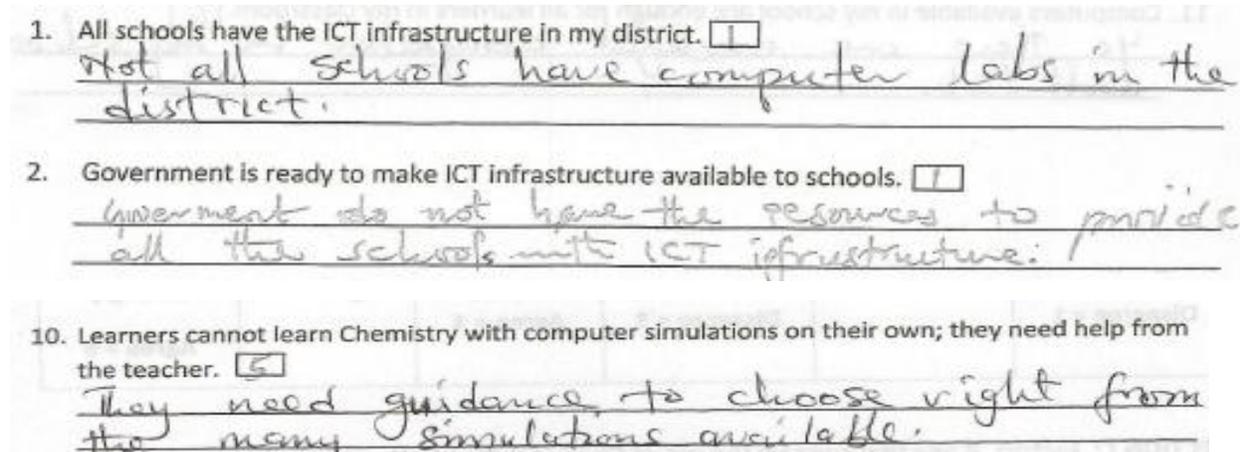
Since the teacher does not find it time consuming to use ICT to teach and learners do not get distracted by ICT in teaching Chemistry, it means that statements eight and nine are eliminated as factors that may hamper the use of ICT to teach learners Chemistry.

Below are the two statements that the teacher disagreed with, which are not seen as problems.

- I find it time consuming to use computer simulations in teaching Chemistry.
- Learners get distracted by ICT during learning of Chemistry.

The teacher also agreed with statement ten. Since the teacher agreed with statement ten it makes it a factor that may hinder the use of ICT to teach. This is because of the way the statement is structured; the respondent agreeing makes it a factor that may hinder the use of ICT to teach. Statement ten in the teachers' questionnaire reads as follows; Learners cannot learn Chemistry with computer simulations on their own; they need help from the teacher.

So from the analysis, the teacher just like the learners stated these facts that availability of ICT infrastructure, the readiness of Government to make ICT infrastructure available in schools and learners needing help from the teacher to use ICT to learn are factors hindering the use of ICT in teaching. Below are also scanned exhibits of the reasons the teacher cited for the ratings he chose.



4.3.3 Questionnaire Analysis: Control Group

4.3.3.1 Section B: The extent to which the control learners are familiar with Computer and its usage

Table 4.7, indicates the responses of the learners of the control group to section B of the learners' questionnaire. This table also has learner-responses grouped into "Agreed" and "Disagreed" and percentages calculated for the responses.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S ₁ D	D	S ₁ D	S ₁ A	A	S ₁ A	Agreed	%	Disagreed	%
One	11	14	3	8	7	8	23	45.1	28	54.9
Two	3	2	4	15	18	9	42	82.4	9	17.6
Three	17	11	3	7	7	6	20	39.2	31	60.8
Four	17	18	3	7	3	3	13	25.5	38	74.5
Five	8	8	3	13	14	5	32	62.7	19	37.3
Six	2	2	0	5	20	22	47	92.2	4	7.8
Seven	1	0	0	0	10	40	50	98	1	2
Eight	4	2	6	11	13	15	39	76.5	12	23.5
Nine	5	5	2	9	13	17	39	76.5	12	23.5
Ten	11	7	5	5	16	7	28	54.9	23	45.1

Table 4.7: Control school Learners' responses to section B of learners' questionnaire.

The above table 4.7 which contains ten items revealed that learners agreed with statements such as two (82.4%) where learners use computers at school, then statement five (62.7%) where learners use internet at home, and the sixth statement which say, "I make use of DVDs and video games", 92.2% of learners agreed to it. Learners also agreed that their school has a computer laboratory (statement seven) and it is connected to the internet (statement eight). Again, 76.5% and 54.9 of learner respondents admitted that there are ICT resources in their community and they make use of the ICT resources like the internet cafes in their community (statements nine and ten). Samples of scanned exhibits of learners' comments are displayed below.

2. I have been using computers at school. 4
Most of the times but not every day

3. I have been using computers at home. 5
Because my brothes has a Computer.

7. My school has a computer laboratory. 5
They do have the laboratory

But 54.9% of learners disagreed with statement one, then 60.8% with three and 74.5% with four. These statements are listed below;

- My Physical Science teacher uses computer simulations to teach.
- I have been using computers at home.
- I make use of internet at school.

Exhibits of what learners had to say about the teacher teaching with simulations;

1. My teacher uses computer and computer simulations to teach. [4]
 They use white board to when they are teaching and writing
1. My teacher uses computer and computer simulations to teach. [2]
 They use a white board marker or a chalkboard to teach

Analysis of statement four indicated that learners claimed that most times they are not allowed to use internet at school. Below are some written comments from the learners' questionnaire;

4. I make use of internet at school. [4]
 we are denied access to internet at school.
4. I make use of internet at school. [1]
 They dont allow us to use internet unless if necessary

From the analysis it is therefore, clear that these learners are familiar with computer and its usage which answers research question two.

4.3.3.2 Section B: The extent to which the control school teacher is familiar with Computer and its usage

Table 4.8 shows the responses from section B of the teachers' questionnaire. From the table, the following deductions can be made. The teacher of the control group disagreed that he uses computer simulation to teach Physical Science because he has no relevant software in this regard (statement two) even though he uses technology to teach. Below is an exhibit of the teacher's comment as it appeared on his questionnaire.

2. I use computer simulations to teach.

I DO NOT HAVE ANY RELEVANT SOFTWARE IN THAT REGARD. ON THE OTHER HAND EVEN IF I CAN HAVE IT, IT NEED ENOUGH TIME

The teacher also responded to statement seven that he does not make use of the ICT resources like internet cafes in the community. The teacher then agreed with the other five statements which are as follows; he uses computer both at home and at school to teach, likewise he makes use of internet and he confirmed that the school has a computer laboratory which is connected to the internet, like his learners said. To answer research question two, it can be said that the teacher of the control group is very familiar with computer and its usage. Table 4.8 is shown below.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _t D	D	S _i D	S _i A	A	S _t A	Agreed	%	Disagreed	%
One						1	1	100	-	-
Two		1					-	-	1	100
Three						1	1	100	-	-
Four						1	1	100	-	-
Five						1	1	100	-	-
SIX						1	1	100	-	-
seven		1					-	-	1	100

Table 4.8: Control school Teachers' responses to section B of the questionnaire.

4.3.3.3 Section C: Factors, if any that hinders the use of Computer Simulations in teaching (Learners' responses)

The control group learners' responses to section C can be seen from table 4.9 below. Basically, 62.7% learners responded negatively that not all the schools in their district have the ICT infrastructure (statement one), and that may be a problem related to using ICT to teach. Also, 54.9% of learners disagreed with statement three that it is time consuming to use computer simulations in learning Chemistry. Again, 64.7% of the learners disagreed that they get confused during the learning of Chemistry when the teacher uses ICT to teach (statement four). And 72.5% of the learners disagreed that they get confused during learning of Chemistry when

using ICT (statement five). The fact that learners disagreed with statements three, four and five nullifies them as factors hindering the use of ICT.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _i D	D	S _i D	S _i A	A	S _i A	Agreed	%	Disagreed	%
One	12	5	15	10	6	3	19	37.3	32	62.7
Two	7	13	3	13	10	5	28	54.9	23	45.1
Three	10	10	8	10	9	4	23	45.1	28	54.9
Four	13	9	11	7	6	5	18	35.3	33	64.7
Five	14	12	11	7	5	2	14	27.5	37	72.5
Six	5	5	2	7	17	15	39	76.5	12	23.5
Seven	3	4	3	9	12	20	41	80.4	10	19.6

Table 4.9: The Control school Learners' responses to section C of the questionnaire.

Meanwhile, learners agreed to statements two, six and seven. Learners (54.9%) agreed with statement two that they get access to computer simulation software programmes. Furthermore, 76.5% reported that they cannot learn Chemistry with computer simulations on their own; they need help from their teacher which makes it a factor just like statement one. For statement seven; computers available in my school are enough for all learners in my classroom was agreed to by learners.

So for research question three to be answered, it could be said that it is inadequate infrastructure and teacher guiding or helping learners to learn with computer simulations which may be the factors hindering the use of Information and Communication Technology to teach and learn. It can therefore be determined that statements one and six are the factors that may hinder the use of ICT to teach. A comment to support inadequate infrastructure by a learner is scanned and is as below:

1. All schools in my district have the ICT infrastructure. ³
Not all of them have ICT infrastructure

Below are scanned exhibits of learners admitting that they need help from the teacher to be able to use computer simulations to learn Chemistry:

I cannot learn Chemistry with computer simulations on their own; I need help from the teacher. [4]

Sometimes. I am not that blank when it comes to computers.

I cannot learn Chemistry with computer simulations on their own; I need help from the

teacher. [6]

Because chemistry sometimes can be confusing

4.3.3.4 Section C: Factors, if any that hinders the use of Computer Simulations in teaching (Teachers' responses)

Table 4.10 below shows the analysis of the control school teacher's responses to section C of the teacher's questionnaire. It can be seen from the table that this teacher disagreed with five of the statements. Of statements one, four, five, eight and nine that the teacher disagreed with, it is statements one, four and five that can be considered as factors which may hinder the use of ICT to teach. Due to the way the statements are structured, the teacher disagreeing makes them factors that may hinder the use of ICT to teach. The statements one, four and five are as follows;

- All schools in my district have ICT infrastructure,
- The time table of the school permits the use of ICT in teaching Chemistry.
- The work load of the Physical Science syllabus allows the use of ICT in learning.

Of statements one, four, five, eight and nine that the teacher disagreed with, it is statements one, four and five that can be considered as factors which may hinder the use of ICT to teach. Due to the way the statements are structured, the teacher disagreeing makes them factors that may hinder the use of ICT to teach. The statements one, four and five are as follows;

- All schools in my district have ICT infrastructure,
- The time table of the school permits the use of ICT in teaching Chemistry.
- The work load of the Physical Science syllabus allows the use of ICT in learning.

STATEMENTS	CODES						Likert scale grouped into Agreed & Disagreed			
	S _t D	D	S _i D	S _i A	A	S _t A	Agreed	%	Disagreed	%
One			1				-	-	1	100
Two					1		1	100	-	-
Three				1			1	100	-	-
Four	1						-	-	1	100
Five	1						-	-	1	100
Six				1			1	100	-	-
Seven					1		1	100	-	-
Eight			1				-	-	1	100
Nine	1						-	-	1	100
Ten					1		1	100	-	-
Eleven					1		1	100	-	-

Table 4.10: The Control school Teachers' responses to section C of the questionnaire.

Statements eight and nine read as “I find it time consuming to use computer simulations in teaching Chemistry (statement eight), and Learners get distracted by ICT during learning of Chemistry” (statement nine). But the teacher disagreed with both of the statements hence they are eliminated as factors. Although the teacher agreed with statement ten which says, “Learners’ cannot learn Chemistry with computer simulations on their own; they need help from the teacher”, this statement is still a factor to be considered. The need to train learners to use computers is also in line with the assertion made by (McTavish, 2009).

To answer research question three, according to the teacher’s responses, one can settle on infrastructure, notional time for Physical Science, work load of the Physical Science syllabus, and assisting learners with computer simulations by teachers, as the factors that may hinder the use of ICT to teach. Below are scanned exhibits of some of the teachers’ views as they appear on the teachers’ questionnaire;

1. All schools have the ICT infrastructure in my district. [3]
SOME DO NOT HAVE
2. Government is ready to make ICT infrastructure available to schools. [5]
GAUTENG - ON - LINE IS INSTALLED TO SCHOOLS WHICH MAKE APPLICATIONS
3. The curriculum support ICT usage in teaching Chemistry. [4]
SOME CD'S WERE PROVIDED IN 2011 BUT THEY FOCUSED ONLY ON ONE KNOWLEDGE AREA, CHEMICAL INDUSTRY.
4. The timetable of the school permits the use of ICT in teaching Chemistry. [1]
THE NOTIONAL TIME FOR TEACHING OF SCIENCE IS SO INADEQUATE. THERE IS NO TIME EVEN FOR DOING PRACTICAL EXPERIMENTS
5. The workload or content of Physical Sciences syllabus allow the use of ICT in teaching. [1]
THE WORKLOAD OR CONTENT PARTICULARLY GRADE 4 IS SO CUMBERSOME, YOU CAN EVEN SEE THE RATE AT WHICH WE'RE SUPPOSED TO TEACH

4.4 Description of Lessons

As indicated in chapter three under methods of data collection, the lessons were organized and presented by the researcher. Below are the descriptions of lessons for the control and the experimental groups.

4.4.1 Lesson of Control Group

The first school was randomly chosen as the control group. The control group was taught Atomic Combinations comprising Atoms, Molecules and Compounds, Bond type, Molecular formulae and IUPAC naming, Oxidation numbers, and Electronegativity using the traditional chalk-talk method. To commence the field work, there was an introductory meeting with the learners of the control school where learners were briefed about the whole exercise. Then a

pre-test was administered, and the researcher started with the lesson presentations (four sections). After which the post-test was written and lastly learners and the teacher responded to the questionnaires. The whole exercise took two and half weeks for each of the schools involved in the study. The usual class teacher of the learners was present as an observer during the lessons, to ensure that the topics under the section were adequately covered by the researcher while the researcher taught the lessons. The teacher did not in any way interfere with instruction. Below are details of the lesson presentations to the learners of the control group.

Lesson One;

The teacher introduced the lesson by going over the periodic table using learners textbook. The teacher spoke about the different groups (1-8) on the periodic table, those that falls under metals and non-metals, as well as the transition metals. Learners were asked to explain how atoms can become ions. Some learners put up their hands and shared their views. The teacher then took learners through concepts such as valence electrons, and valency using the atomic structure. For example, sodium atom (Na) loses its outermost electron (valence electron) to become positively charged ion (cation) called sodium ion (Na^+). It is the same way chlorine atom (Cl) gains one other electron to itself and become negatively charged ion (anion) called chlorine ion (Cl^-) and so on. The learners listened and copied the examples and other salient points into their note books.

Lesson Two;

After looking at the periodic table and all there is to know about it in the preceding lesson, learners were taken through the use of chemical symbols to represent atoms, like O for oxygen, H for hydrogen, Na for sodium and Mg for magnesium and on and on. The lesson went on where chemical formulae were taught alongside naming of the molecules and compounds bearing in mind their common names and their IUPAC names. The researcher made learners aware of 'how' and 'which' atoms can combine to form a compound. For instance, lithium and sodium cannot combine to form a compound because they both carry positive charges; the

same way two negative charge carrying atoms cannot combine under normal circumstance to form a compound. It was also made known to learners that when atoms combine to form compounds, part of their names does not remain the same. For example, when calcium and oxygen combine, they become calcium oxide. The second atom (oxygen) has 'ide' replacing its last four letters to become oxide.

Lesson Three;

The lesson started with leading questions such as what do you understand by chemical bonding? Name any type of bond you are familiar with and how are these bonds formed? The learners tried to respond to these questions as much as they could. The researcher then build on learners' previous knowledge by teaching what chemical bonding is, the types of bonds there are but concentrating on covalent and ionic bonds in accordance with the NCS work schedule for term one, 2012. How these bonds are formed and their unique properties were explained by the researcher. The researcher wrote the salient points on the chalk board while the learners jot down the points in their note books. The learners asked questions where necessary for more clarifications. Much time was spent on how to represent covalent bonds using the Lewis and the Couper structures (section 2.9.3 of this study).

Lesson four;

During the final lesson, Oxidation numbers, how to calculate the Oxidation numbers, and Eletronegativity were treated. The researcher enumerated the rules to use to determine Oxidation numbers and elaborated them to learners. The lesson proceeded with examples on how to calculate the Oxidation numbers of some compounds. Few learners were invited to the chalk board to calculate say the Oxidation number of carbon in carbon dioxide and so on. Some examples of Oxidation number calculations are shown below;

- Calculate the oxidation number of Cl in ClO_3^-

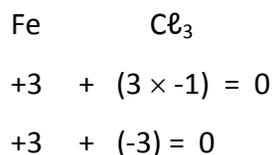


$$\text{Cl} + (3 \times -2) = -1$$

$$\text{Cl} + (-6) = -1$$

$$\text{Cl} = -7$$

- What will the oxidation number of the elements in iron (III) chloride (FeCl_3) be?



The researcher then went on to teach learners about Electronegativity; clarifying the concept in relation to non-polar bond (example H_2) and polar bond (example HCl). The learners paid attention and wrote down important points in their note books. The lessons came to a successful end as the researcher was able to teach the topics within the specified time.

4.4.2 Lesson of Experimental Group

For the second school, chosen randomly as the experimental group, learners were taken through the same procedures as the control group. The experimental group was taught using normal teaching method and computer simulations on the same areas of Atomic Combinations as listed above. The computer simulations used in this research were those from Plato Learning Centre (2005) based in the UK, for more information visit [www.http://platolearning.co.uk](http://platolearning.co.uk).

The use of the computer simulations in the teaching served as an intervention in this study. At the time of the presentations, the internet connections of the experimental school which they receive through the Gauteng-on-line were down, so the researcher could not download Java software to be able to play the simulations. Also, the researcher could not get multiple or network license for the Interactive Chemistry Simulations to install the simulations on all computers in the computer laboratory. For these reasons, the experimental group had their lessons in the Science laboratory. During the lessons, the usual class teacher of the learners was present as an observer to ensure that the topics under the section were adequately covered by the researcher while the researcher taught the lessons. The teacher did not interfere in any way with the instruction.

As stated above the initial plan was to install the software on the computers in the computer laboratory so that individual learners would interact directly with the simulations. But because it became virtually impossible to install the software for the learners to have individual contact with the simulations, the researcher used her personal lap top and data projector to teach instead of each learner sitting by a computer and working through the simulations from the Plato Learning Center. But there was absolutely no problem with the new arrangement, and the learners cooperated throughout the lesson. They did not see anything wrong with the usage of the data projector to project the simulations onto a big white screen for their view.

It was observed that during the teaching, the learners generally responded positively and showed much enthusiasm to the use of computer simulations to teach them. Hartley, Treagust, & Ogunniyi (2007) also reported that learners were excited when they carried out a research on the application of computer-assisted learning strategy in Science and Mathematics for disadvantaged Grade 12 learners in South Africa. Below are screenshots of the simulations from Plato learning centre and how they were used during the lessons.

Lesson One;

As in the case of the control group, the periodic table was revised by way of introduction. Below is the screenshot of the periodic table showing all the elements in their different groups from 1 to 8. Colours have been used to categorise the elements into Alkali metals, Alkaline earth metals, transition metals to name just but a few. The simulation of the periodic table has the groups, temperature, timeline and properties tabs as shown on the screenshot. When you click on temperature, you are able to read the boiling points and melting points of the elements. It also gives the timeline, that is when the elements were discovered, and the simulation shows the properties of the elements like the density, mass number, atomic radius and so on. Hence the different 'groups' of elements on the periodic table and their properties were dealt with thoroughly. As usual, the learners listened, participated where necessary and made notes in their books for future reference.

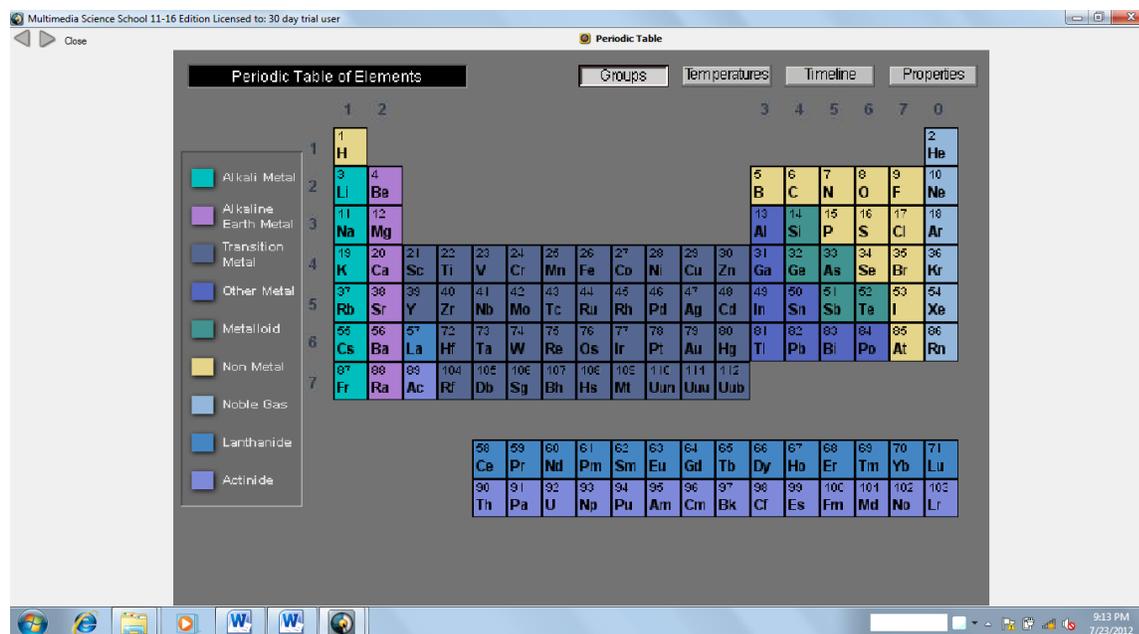


Figure 4.1: Screenshot of periodic table from the Plato learning centre showing all the elements.

Lesson Two;

The researcher gave further interpretations concerning the first twenty elements, stating the number of electrons on each orbital of the atoms and how they should be arranged, among other things. The next screenshot is about the atomic structure of the first twenty elements but then, these atomic structures are presented on the periodic table. The learners watched and listened attentively to the researcher as the lesson proceeded. With this simulation, the researcher was able to focus on the outer shells. The simulation has an option button with which one can choose to see the atomic structures as shown on the screen or substances such as metals and non-metals. It has the ability to allow one to view all shells or only the outer shells of the elements and the outer shells can be highlighted as well. During the lesson, the learners asked many questions, for example, how many electrons must be on the third shell? The researcher gave further clarifications on the questions. Below is figure 4.2, showing the atomic structures of the first twenty elements on the periodic table.

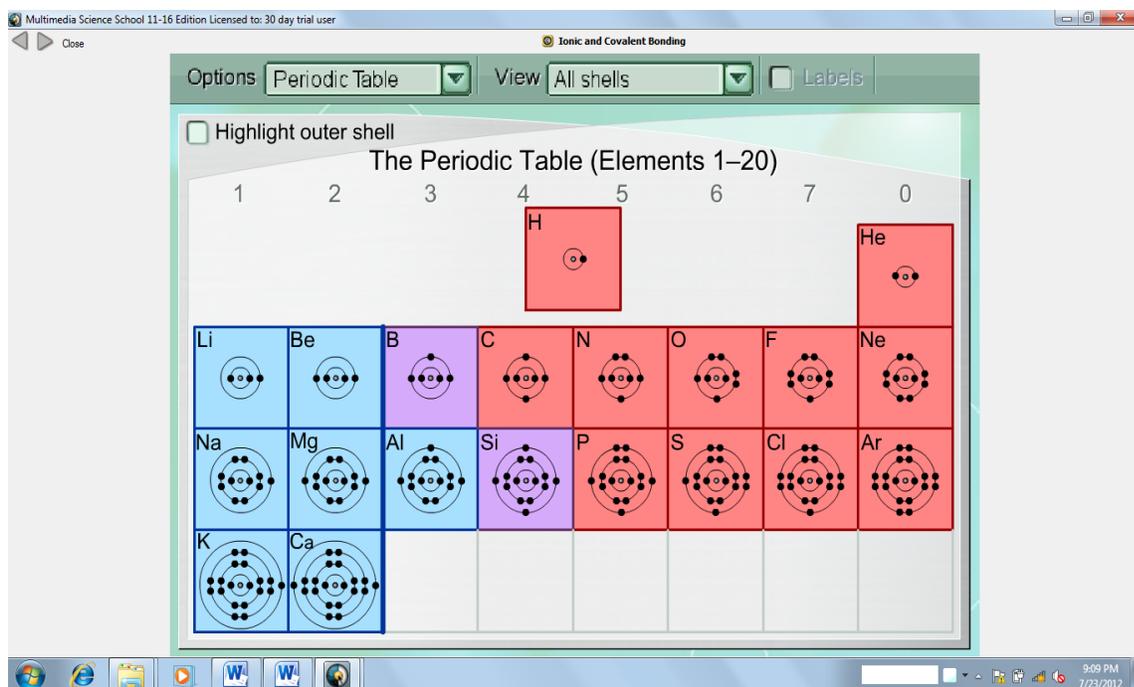


Figure 4.2: Screenshot of Atomic structure (elements 1-20) from the Plato learning centre.

Lesson Three;

The atomic structure discussion was then linked to Valence electrons, Valency and Electronegativity using the screenshot below (figure 4.3) to explain the details. This simulation is also on the first twenty elements (from hydrogen to calcium). Each element that is selected, its electronic configuration is displayed making it possible to know the number of the valence electron when even the shell diagram option is not chosen on the simulation screen. The researcher then moved on to teach Oxidation states, the rules concerning the oxidation states and elaborated on its calculations to the learners.

For example, calculate the oxidation number of Manganese (Mn) in KMnO_4 .

$$\begin{aligned} & \text{K} \quad \text{Mn} \quad \text{O}_4 \\ & +1 + \text{Mn} + (4 \times -2) = 0 \\ & \text{thus: } \text{Mn} = +7 \end{aligned}$$

The learners participated actively by going through more calculations of the oxidation states and did some discussions among themselves. They also put down salient points in their book.

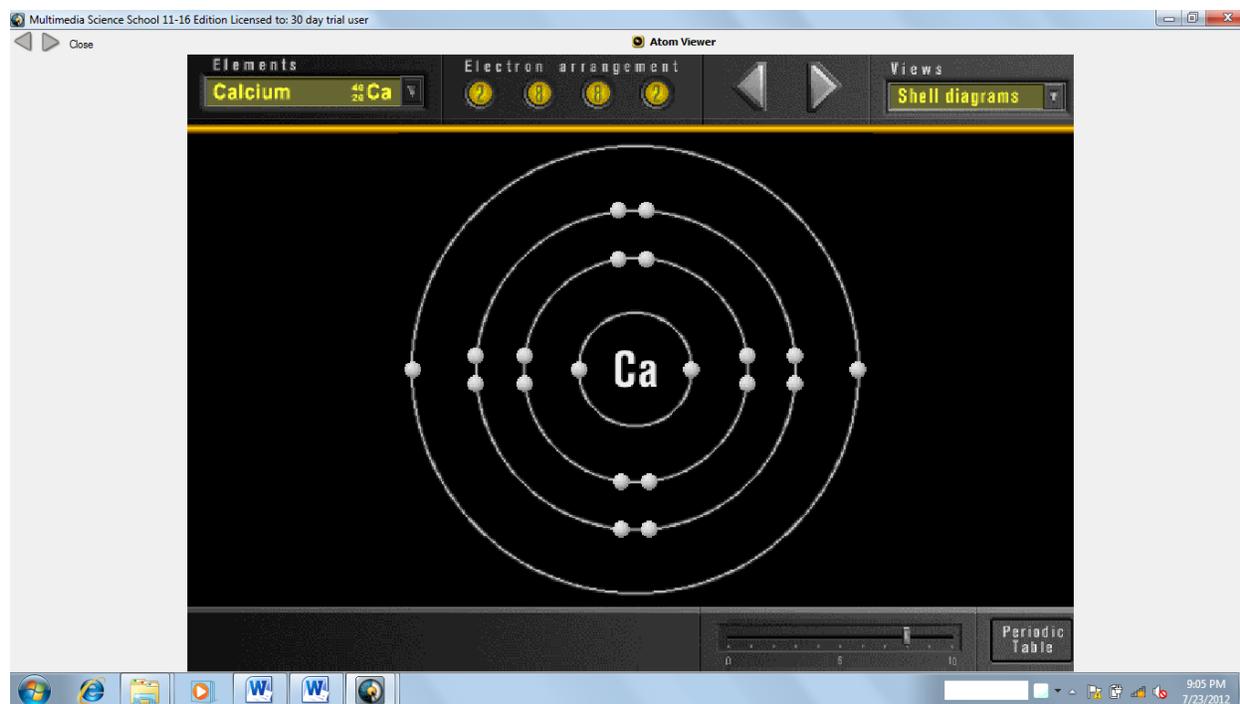


Figure 4.3: Screenshot of the structure of Calcium Atom from the Plato learning centre.

Lesson Four;

Figure 4.4 and 4.5, shows screenshots of the bond types namely Covalent bond and Ionic bond which were used to teach the Lewis structure and Couper structure. Learners were asked to enumerate properties of Covalent bond and Ionic bond and how these bonds are formed, of which the learners attempted to. The researcher then explained chemical bonding to the learners. The researcher used simulations to show how these bonds are formed as can be seen in the figures below. Different Covalent bonds were formed between non-metallic elements, for example carbon and oxygen to form carbon dioxide, carbon and hydrogen to form methane and so on. The simulation on covalent bond gives the formula, name, mass and composition of the compound formed. Even though, there was no simulation on Lewis and Couper structures specifically, the researcher used power point presentation and demonstrated how to represent these structures.

to support learners reach their level of potential development from their actual level of development.

The simulations were interactive and brought about discussions and participation among the learners. This is also noted by Perkins, Adams, Dubson, Finkelstein, Reid, Wieman and LeMaster (2006); Linn, Eylon and Davis (2004) in their study that interactive simulations are a new way to transfer scientific ideas and connect learners in educational activities.

4.5 Summary

In this chapter, the data collected during the research have been presented, described, the results analyzed and discussed. The results from this study provided answers to the research questions based on the data collected and analyzed. As a result, the null hypothesis has been accepted.

CHAPTER FIVE

CONCLUSION

5.1 Overview

In this chapter the main findings of this study are summarized, and conclusions drawn. It also provides implications, recommendations, limitations and suggestions for further study. This study set out to look at the effects of computer simulations on the teaching of Atomic Combinations to grade eleven Physical Science learners. The study took place in Tshwane North District in the Gauteng Province, South Africa. The sample comprised 105 high school learners and two teachers. This study endeavoured to address the three research questions that directed the study.

5.2 Major Findings

The Government, through the Department of Education believes that ICT “have the potential to improve the quality of education and training” and this is what this research sought to elicit (DoE White Paper on e-education, 2004). One of the fast growing computer technologies which can aid learners to learn as well as the teachers to teach Physical Science concepts particularly in Chemistry is computer simulations and these computer simulations can support the modeling of Physical Science concepts and processes. Below are the main findings of this study subtitled according to the research questions.

5.2.1 Effect of Computer Simulation

To answer research question one, the scores from the pre-test and the post-test of both experimental group and control group were analyzed using SPSS version 16.0 and a t-test

calculated. The calculated t-test was used to test the null hypothesis. In this study, the control group was taught using the normal traditional way while the experimental group was taught the normal way and with computer simulations. The result of the mean scores (table 4.1) showed that the experimental group performed better than the control group in the post-test, meanwhile, the control group got a higher mean score in the pre-test compared to the experimental group. But the t-test result revealed that there is no statistical significant difference between the post-test scores of the experimental group and the control group.

5.2.2 Familiarity with computers

The data from this study were quantitative and so research question two (section B for both learners' and teachers' questionnaires) was analyzed quantitatively. In order to answer this question, the researcher further grouped responses on the questionnaire into "Agreed" and "Disagreed" and then looked at "for" and "against" responses. The teacher respondents of the experimental group agreed with all statements on section B of the teachers' questionnaires. The learners' also agreed with all statements on section B of the learners' questionnaires in exception of statements four and five (table 4.3). Statements four and five are the ones listed below;

- I make use of internet at school.
- I make use of internet at home.

For the control group, the teacher respondent agreed with the learner respondents to say;

- The Physical Science teacher does not use computer simulations to teach.

On the part of the teacher respondent, the teacher indicated that he does not make use of the ICT resources like internet cafes in the community (refer to section 4.3.3.2). While the learners said they do make use of the ICT resources like internet cafes in their community.

But the learners differed from their teacher on the two statements below (section 4.3.3.1).

- We do not use computers at home.

- We do not make use of internet at school.

The following are the deductions drawn;

Learners are not allowed to use internet at school unless in special cases where they have to do research for an assignment but with the teacher's permission. The learners use the internet also for research during CAT or IT class. Other learners reported that they make use of internet at home only when it is needed for an assignment with their parent's permission. Otherwise, most of the learners do not make use of internet at home. This may probably be due to financial constraints considering the rural nature of the geographical location of the schools where this study was done.

5.2.3 Hindrances to Computer Usage

The research question three was also answered by the help of the questionnaire. From the analysis of section C of the learners' and teachers' questionnaire, which covers research question three for the experimental group revealed that both learners and teachers identified two statements as a problem to the use of ICT to teach (see section 4.3.2.3). These are;

- All schools in my district have ICT infrastructure.
- Learners cannot learn Chemistry with computer simulations on their own; they need help from the teacher.

The teacher indicated that Government is not ready to make ICT infrastructure available to schools.

For the control group, the teacher as well as the learners established two statements as factors that may be hindering the use of ICT to teach. They agreed that

- All schools in their district do not have ICT infrastructure and
- Learners cannot learn Chemistry with computer simulations on their own; they need help from the teacher (see section 4.3.3.4).

According to the DoE White Paper on e-education (2004; 1.24) there are still more than 19 000 schools without computers for teaching and learning in South Africa. The views (disagreement) of the respondents who took part in this study also confirm this statement.

The respondents came out clearly that they do not get confused using ICT to learn Chemistry. They also came out clearly that there are enough computers in their schools for every learner in the class. And that they can get access to computer simulation software programmes.

5.3 Conclusions

The effects of computer simulations on the teaching of Atomic Combinations were investigated in this study. It was found that the simulations did not significantly influence the performance of learners in the experimental group over the control group. This led to the acceptance of the null hypothesis which stated that there is no statistically significant difference in Chemistry achievement between learners taught Atomic Combinations with the use of computer simulations and others taught with traditional lecture method. Although, there was no significant difference between the two groups in terms of academic performance, however, the learners responded well and showed much enthusiasm after using computer simulations as a tool for learning. Hence, one can say that the objective (object) of using an interactive learning approach based on the use of the Activity theory in this study was successful. This finding is in line with (Arowolo, 2009 and Kotoka & Ochonogor, 2012) where computer-assisted instruction were used to teach but the experimental group showed no significant improvement in their post-test results over that of the control group. In the same vein, Liu et al. (1998) found that there was no significant effect of computer integration on achievement or in learners' attitude toward computers after computer integration, just as Hsu and Thomas (2002) found no significant differences on post-test scores of the experimental and control groups. It is therefore suggested that more research be carried out in this field to enable the generalization of the findings.

However, the researcher can confidently say both teachers and learners are familiar with computer and its usage in the research schools to a large extent (research question two) because the findings point to the fact that on the whole, learners and teachers make use of computers, use internet when needed at school or home and sometimes in the internet cafes in their community. The above conclusion is also in accordance with the e-Education policy goal which states that “Every South African learner in the General Education and Training (GET) and Further Education and Training (FET) bands will be ICT capable by 2013”. This implies that learners are able to use ICT confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community (DoE White paper, 2004).

Finally, to conclude on research question three which was designed to solicit views for factors that may hinder using computer simulations to teach Chemistry. The teachers just like their learners together pointed out the following as factors that may be hindering the use of ICT in teaching Chemistry;

- Inadequate ICT infrastructure in schools,
- Government’s readiness to provide the ICT infrastructure, and
- Teachers assisting learners to be able to use ICT,

5.4 Implications

The findings from this study have implications for educational stakeholders such as Researchers, Teacher Trainers, Science teachers, Learners, Curriculum planners, Department of education and Society at large. Also, this study contributes to literature in the following ways; the use of computer simulation does not always have significant effect on learners performance; it has therefore provided review of the Activity theory model of instruction; the study, has also added literature to the use of computer simulation in the teaching and learning of Science.

Most essentially, it has called for more attention towards using computer simulations to teach Atomic Combinations in Chemistry lessons or any other Chemistry topic for that matter. This may also encourage teachers to teach in line with the constructivist theory of learning which stipulate that learners learn better through activities (tools like computer simulations); a theoretical framework that guided this study. After teaching learners with the computer simulations, it was observed that when learners are being taught using ICT, it whips up their interest and captures their attention as well (refer to section 4.2.3).

5.5 Recommendations

Considering the outcomes of this study, the following recommendations are made by the researcher;

- Future studies should allow more time for learners to be more fully immersed in the program or absolutely benefit from the intervention. In other words, learners should be given extended opportunity in order to allow them optimum practice to really get use to how to simulate using given software.
- Government and other ICT companies should collaborate to prepare educational software on simulations of various experiments and activities that are relevant to the South African curriculum and should be made available to teachers and learners.
- The Department of education should ensure that internet services are available to the schools.
- Government should endeavor to provide adequate ICT infrastructure to most schools if not all schools. If possible Government should provide laptops to teachers at a very subsidized price.
- Teacher trainees in teacher training institutions should be given ICT pedagogical training so that they would have good ICT skills in terms of their own personal use, and they would be able to transfer these skills by using ICT in the classroom.

- Workshops and seminars on the use of ICT in the teaching-learning process should be increased.

5.6 Limitations of the Study

There were some constraints which surfaced during the course of this study. These constraints are enumerated as follows;

A limitation to the study was the disconnection of the internet services in the schools where the study took place. Hence the researcher could not download java to play the simulations on individual computers as intended. All the same, steps were taken by the researcher to ensure that the intervention took place as mentioned earlier on (refer to section 4.4.2).

Also, the simulation software used was meant for teaching and learning Science, it was not tailored strictly according to the South African curriculum but had to be used to conduct the study as shown in chapter four.

Last but not the least, there was what the researcher will term curriculum constraint, that is, the topic Atomic Combinations was scheduled for two weeks in the NCS work schedule for term one, 2012 so the researcher had to work within a time frame.

5.7 Suggestion for further Study

The result of this research shows 'no significant difference between the performance of the experimental group and the control group. It is therefore suggested that further studies be conducted bearing in mind the nature of the topics in the Chemistry syllabus, in order to find out whether the benefits of simulations depend on the nature of the topic. In a different study, Bayraktar (2002) found that physics had the largest mean effect and concluded that CAI was

most effective in Physics compared to the other Science subjects (Chemistry, Biology and General Science).

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Consent form for parents

I _____ the parent of
_____ hereby grant consent to Kotoka Love to allow my child to be part of her research. The data that will be collected from my child and his/her class should only be used for research purposes and paper presentation at conferences. The data collected should be treated with confidentiality and neither the name of the school, my child or the teacher be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

Parents Signature: _____ Date: _____

Child's name _____ Child's Signature: _____ Date: _____

Consent form for Learner participants in the study

I,, of(school) have read and understood the procedures involved in the study and what is expected of me as a participant. I understand that my name and identity will be protected in the study. I willingly give the following consent:

Please put a tick in the appropriate box

I am willing to participate in the study

I give consent for being observed during my Physical Science lessons

I give consent for my Physical Science notebook being checked

I give consent for part(s) of my Physical Science notebook to be photocopied if necessary

The data collected shall be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time. The extra copy of this form is for you to keep.

Thank you.

Signature of learner Date

Name (Please print)

Letter to the Principal

Dear Principal,

I am Kotoka Love, a full time teacher at Hammanskraal Secondary School, and a Master's student at UNISA. As a requirement for the award of a Master of Science degree in Science, Mathematics and Technology Education, I am investigating the effects of computer simulations on the teaching of Atomic Combinations to grade 11 Physical Science learners.

I would like to humbly request your permission to use a computer simulation to teach the learners in Grade 11, administer a pre-test, post-test and questionnaires to collect data from them by the help of the class teacher(s). There would be no interruption of your normal school programme, I would follow the normal school time table and the researcher would use the computer simulation to teach Atomic Combinations to an experimental group in the computer lab while a control group will be taught using the traditional (normal) teaching methods. After the intervention, I would collect data by learners answering a post-test and a questionnaire. Teacher(s) on the other hand will only answer a questionnaire. The data collected will be treated with confidentiality and the names of your school, the teachers and the learners will not be used in the analysis of the data.

The teacher(s) may benefit from the research since they would be allowed to observe the lessons and the use of the intervention. The learners would also benefit from the method of instruction as it is hoped that this would enhance their understanding of the concepts.

Please do not hesitate to contact me if you have any further queries or clarifications. My contact details are as follows:

Cell number: 0725746200.

Email: kotokalove@gmail.com

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

()

Kotoka Love.

Consent form for principal

I _____ the principal of
_____ School, hereby grant consent to Mrs.

Kotoka Love, to involve the Grade 11 learners and teacher(s) in her research.

The data collected should be treated with confidentiality and the name of the participants (Teachers and learners) should not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

Signature: _____ Date: _____

Letter to the teacher

Dear Teacher,

I am Kotoka Love, a full time teacher at Hammanskraal Secondary School, and a Master's student at UNISA. As a requirement for the award of a Master of Science degree in Science, Mathematics and Technology Education, I am investigating the effects of computer simulations on the teaching of Atomic Combinations to grade 11 Physical Science learners. I would like to request you to be part of my study. The study will involve the use a computer simulation to teach learners in Grade 11 Physical Science. I would follow the normal school time table and will use the computer simulation to teach Atomic Combinations to an experimental group in the computer lab whiles a control group will also be taught using the traditional (normal) teaching methods. After the intervention, I would collect data by learners answering a post-test and a questionnaire. You on the other hand will only answer a questionnaire.

Participation in this research is voluntary and there will be no victimization whatsoever for refusal to participate. There would be no interruption of your normal school programme. The data collected will be treated with confidentiality and the names of your school, yourself and learners will not be divulged. It is hoped that you may benefit from the research since you would be allowed to observe the lessons and the use of the intervention. The learners would also benefit from the method of instruction as it is hoped that this would enhance their understanding of the concepts.

Please do not hesitate to contact me if you have any further queries or clarifications. My contact details are as follows:

Cell number: 0725746200.

Email: kotokalove@gmail.com

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

()

Kotoka Love.

Consent form for teachers to participate

I _____ a teacher at

_____ School hereby grant consent to Mrs.

Kotoka Love, to be part of her research. The data that will be collected from me and my class should only be used for research purposes and conferences.

The data collected should be treated with confidentiality and the name of the participants (Teachers and learners) should not be mentioned in the analysis of the data. The Participants (teachers and learners) may withdraw from the study at any time.

Signature: _____ Date: _____

Letter to the Provincial Education Office.

Dear Sir/Madam,

I am Kotoka Love, a full time teacher at Hammanskraal Secondary School, and a Master's student at UNISA. As a requirement for the award of a Master of Science degree in Science, Mathematics and Technology Education, I am investigating the effects of computer simulations on the teaching of Atomic Combinations to grade 11 Physical Science learners.

I would like to humbly request your permission to use a computer simulation to teach learners in Grade 11, administer a pre-test, post-test and questionnaires to collect data from the Grade 11 Physical Science learners by the help of the class teacher(s) in two schools in the province.

There would be no interruption of normal school programme, I would follow the normal school time table and would use the computer simulation to teach Atomic Combinations to an experimental group in the computer lab while a control group will be taught using the traditional (normal) teaching methods. After the intervention, I would collect data by learners answering a post-test and a questionnaire. Teacher(s) on the other hand will only answer a questionnaire. The data collected will be treated with confidentiality and the names of the school, the teachers and the learners will not be used in the analysis of the data. The teacher(s) may benefit from the research since they would be allowed to observe the lessons and the use of the intervention. The learners would also benefit from the method of instruction as it is hoped that this would enhance their understanding of the concepts.

Please do not hesitate to contact me if you have any further queries or clarifications. My contact details are as follows:

Cell number: 0725746200.

Email: kotokalove@gmail.com

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

()

Kotoka Love.

28 April, 2011

Department of Education,
Gauteng

Re – Introduction of Mrs. Love Kotoka: a M.Sc. Chemistry Education Research Student.

I hereby introduce the bearer, Mrs. Love Kotoka as one of my students for the degree of M.Sc. in Chemistry Education at the Institute for Science and Technology Education, University of South Africa as follows:

Name & title: Love Kotoka (Mrs.)

District of Interest: Gauteng North District.

The topic of dissertation: EFFECTS OF COMPUTER SIMULATIONS ON THE TEACHING OF pH – VALUES TO GRADE 11 PHYSICAL SCIENCE LEARNERS.

Research school(s): Physical science schools with grade 11 classes.

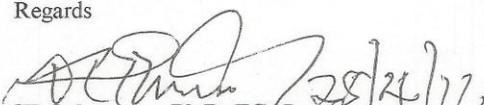
The aim: To determine the effect of Computer Simulations usage on the teaching of pH-Values to grade 11 physical science learners.

The collection of data: Contact time during the teaching of physical science to the grade 11 learners in about two weeks. The learners will be expected to complete pre - and post tests in order to determine the influence of the intervention and will also be completing a structured questionnaire to verify the data.

The need: This research will be to the benefit of the Gauteng Education Department if the recommendations from the study there after could be implemented. Furthermore, the outcome of the research shall aid the certification of the researcher.

Conclusion: I therefore recommend Mrs. Kotoka for your unreserved help to achieve the objectives of her study, please.

Regards


CE Ochonogor, Ph.D; FCAI 28/4/11



2 June, 2011

Our Ref: 2011/ISTE/009

Mrs. Love Kotoka

South Africa

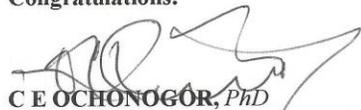
Dear Mrs. Kotoka,

REQUEST FOR ETHICAL CLEARANCE: Effects of Computer Simulations on the Teaching of pH-values to Grade 11 Physical Science Learners

Your application for ethical clearance of the above study was considered by the ISTE sub-committee on behalf of the Unisa Research Ethics Review Committee on 20 January, 2011.

After careful consideration, your application is hereby **approved** and hence you can continue with the study at this stage.

Congratulations.



C E OCHONOGOR, PhD
CHAIR: ISTE SUB-COMMITTEE

cc. PROF T S MALULEKE
EXECUTIVE DIRECTOR: RESEARCH

PROF M N SLABBERT
CHAIR- UREC.





GDE RESEARCH APPROVAL LETTER

Date:	12 October 2012
Name of Researcher:	Kotoka L.
Approval for period:	6 February 2012 to 29 September 2012
Address of Researcher:	P.O. Box 23814
	Gezina
	Pretoria
	0031
Telephone Number:	072 574 6200
Email address:	kotokalove@gmail.com
Research Topic:	Effects of Computer Simulation on the teaching of PH values to Grade 11 Physical Science learners
Number and type of schools:	TWO Secondary Schools
District/s/HO	Tshwane North

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*

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Making education a societal priority

Office of the Director: Knowledge Management and Research

9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

3. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
4. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
12. On completion of the study the researcher must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
14. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

David Makhado

Dr David Makhado

2011/10/14

Director: Knowledge Management and Research

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APPENDIX B: TEST

PRE-TEST ON ATOMIC COMBINATIONS

TOTAL: 60MARKS

Name: Date: Class: Duration: 40 - 45 minutes.

Part I: Multiple choices (2 Marks each)

INSTRUCTION: Write down or circle the letter that best completes the statement or answers the question.

1. Which best describes a covalent bond?

- a. transfer of electrons from one type of atom to another
- b. the attraction between a positive ion and a negative ion
- c. sharing of a pair of electrons between two atoms
- d. gravitational force between the nuclei of two atoms

2. In the Lewis structure, what do the dots represents?

- a. protons
- b. neutrons
- c. valence electrons
- d. shell

3. Which is an example of a diatomic molecule?

- a. HCl
- b. Br₂
- c. CO
- d. NaCl

4. Which of the following has the greatest electronegativity?

- a. H
- b. Cl
- c. O
- d. F

5. Which one of the following is **NOT** true about elements that form cations?
- a. The atoms lose electrons in forming ions
 - b. The elements are metals
 - c. They are located to the left of the periodic table
 - d. They have high electron affinities
6. Which of the following pairs of atoms are least likely to form an ionic compound?
- a. Ni, O
 - b. Na, F
 - c. Cu, Cl
 - d. Li, Mg
7. What kind of bond results when electron transfer occurs between atoms of two different elements?
- a. ionic
 - b. covalent
 - c. nonpolar
 - d. single
8. What is the correct formula of phosphorus pentachloride?
- a. PCl_3
 - b. PCl_5
 - c. P_2Cl_5
 - d. P_5Cl

9. The nucleus is very _____ compared to the atom as a whole.

- a. small
- b. large
- c. similar
- d. light

10. All of the following are examples of compounds except ...?

- a. table salt, NaCl
- b. vinegar, H₃COOH
- c. ozone, O₃
- d. laughing gas, N₂O

11. Which type of bond would you expect to find when two non-metals are combined?

- a. covalent bond
- b. ionic bond
- c. physical bond
- d. metallic bond

12. What are the two principal types of bonding called?

- a. ionic bonding and covalent bonding
- b. ionic bonding and polar bonding
- c. metallic, ionic and covalent bonding
- d. polar bonding and covalent bonding

13. Write the chemical formula of sodium phosphate.

- a. Na₃PO
- b. Na₃PO₄
- c. Na₄PO₃
- d. NaPO₄

14. Name the two classes of element which are most likely to form an ionic compound if they are allowed to react with each other.

- a. metal and metal
- b. metal and nonmetal
- c. nonmetal and nonmetal
- d. semimetal and nonmetal

15. What is the name of Cu_2O ?

- a. sodium phosphate
- b. copper (II) oxide
- c. copper dioxide
- d. copper oxide

16. Write the formula of sodium carbonate.

- a. NaCO
- b. NaCO_3
- c. Na_2CO
- d. Na_2CO_3

17. What is the oxidation number of Mn in KMnO_4 ?

- a. + 5
- b. + 6
- c. + 7
- d. + 8

18. Provide the name of CCl_4 .

- a. Carbon Chloride
- b. Carbon (IV) Chloride
- c. carbon tetrachloride
- d. Carbon Chloride tetra

19. Give the formula of the compound whose name is Dinitrogenpentoxide.

- a. N_2O
- b. N_2O_5
- c. NO_5
- d. N_5O_2

20. What is the name of the ion HCO_3^- ?

- a. hydrogen carbon oxide
- b. hydrogen carbon trioxide
- c. hydrogen carbon oxygen
- d. hydrogen carbonate

Part II: True or False (2 Marks each)

Indicate whether the following statements are true or false by circling the appropriate letter either true ("T") or false ("F") in front of the sentence.

- 21. An atom is the smallest complete piece of matter which cannot be broken down. **T/ F**
- 22. An element is a simple pure substance. **T/ F**
- 23. Thomson discovered electrons in the early 1800's. **T/ F**
- 24. The center of the atom is the nucleus. **T/ F**
- 25. The electron cloud swirls around the inside of the atom. **T/ F**
- 26. Chemical symbols are used to represent electrons. **T/ F**
- 27. A molecule is two or more atoms with specific properties that have bonded together. **T/ F**

28. Chemical formulae cannot be used to symbolize chemical substances such as compounds.

T/ F

29. Protons are the negatively charged particles in the atom. **T/ F**

30. A subscript is a small number written above a letter or number. **T/ F**

APPENDIX C: QUESTIONNAIRES

A QUESTIONNAIRE FOR LEARNERS ON USING COMPUTER SIMULATIONS IN TEACHING CHEMISTRY

All answers to questions contained in this questionnaire will be treated confidentially.

For the purpose of this questionnaire, computer simulation is defined as an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. Also, Information and Communication Technology (ICT) is defined as a range of technologies for gathering, storing, retrieving, processing, analyzing and transmitting information like computers, projectors and internet.

Instructions: Please tick or fill in where necessary.

SECTION A: Personal Information

1. Name of Learner: _____

2. Type of School: Day Boarding

3. Gender: Male Female

4. Age:

13 -15 years

15 - 17 years

17 - 19 years

over 19 years

5. Race:

6. Home Language:

Instructions: For sections B and C, use the codes given, by writing a code (e.g. 1, 2, 3, 4, 5 or 6) of your choice against the questions. The codes are given below. For each question, give reason(s) for the choice made on the space provided where necessary.

SECTION B: The extent to which learners are familiar with Computer and its usage.

Strongly Disagree = 1	Disagree = 2	Slightly Disagree = 3	Slightly Agree = 4	Agree = 5	Strongly Agree = 6
----------------------------------	---------------------	----------------------------------	-------------------------------	------------------	-------------------------------

1. My Physical Science teacher uses computer simulations to teach.

2. I have been using computers at school.

3. I have been using computers at home.

4. I make use of internet at school.

5. I make use of internet at home.

6. I make use of DVDs, and/or Video games at home.

7. My school has a computer laboratory.

8. My school's computer laboratory is connected to the internet.

9. There are ICT resources (e.g. internet cafes) available in my community.

10. I make use of the ICT resources like internet cafes in my community.

SECTION C: Factors, if any that hinder the use of Computer Simulations in teaching.

Strongly Disagree = 1	Disagree = 2	Slightly Disagree = 3	Slightly Agree = 4	Agree = 5	Strongly Agree = 6
----------------------------------	---------------------	----------------------------------	-------------------------------	------------------	-------------------------------

1. All the schools in my district have the ICT infrastructure.

2. I can get access to computer simulation software programmes.

3. I find it time consuming to use computer simulations in learning Chemistry.

4. I get confused during the learning of Chemistry when my teacher uses ICT.

5. I get confused during learning of Chemistry when using ICT.

6. I cannot learn Chemistry with computer simulations on my own; I need help from my teacher.

7. Computers available in my school are enough for all learners in my classroom.

A QUESTIONNAIRE FOR TEACHER(S) ON USING COMPUTER SIMULATIONS IN TEACHING CHEMISTRY

All answers to questions contained in this questionnaire will be treated confidentially.

Instructions: Please tick or fill in where necessary. For the purpose of this questionnaire, Information and Communication Technology (ICT) is defined as a range of technologies for gathering, storing, retrieving, processing, analysing and transmitting information like computers, projectors and internet. A computer simulation is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works.

SECTION A: Personal Information

1. Name of Learner: _____

2. Type of School: Day Boarding

3. Gender: Male Female

4. Age:

20 -25 years

25 - 30 years

30 - 35 years

over 35 years

5. Qualifications:

Academic _____

Professional _____

Others _____

6. Race:

7. Home Language:

Instructions: For sections B and C, use the codes given, by writing a code (e.g. 1, 2, 3, 4, 5 or 6) of your choice against the questions. The codes are given below. For each question, give reason(s) for the choice made on the space provided where necessary.

SECTION B: The extent to which the teacher is familiar with Computer and its usage

Strongly Disagree = 1	Disagree = 2	Slightly Disagree = 3	Slightly Agree = 4	Agree = 5	Strongly Agree = 6
----------------------------------	-------------------------	----------------------------------	-------------------------------	------------------	-------------------------------

1. I have been using computers at home, and in school to teach.

2. I use computer simulations to teach Physical Science.

3. I make use of the internet.

4. My school has a computer laboratory.

5. My school's computer laboratory is connected to the internet.

6. There are ICT resources (e.g. internet cafes) available in my community.

7. I make use of the ICT resources like internet cafes in the community.

SECTION C: Factors, if any that hinder the use of Computer Simulations in teaching.

Strongly Disagree = 1	Disagree = 2	Slightly Disagree = 3	Slightly Agree = 4	Agree = 5	Strongly Agree = 6
----------------------------------	---------------------	----------------------------------	-------------------------------	------------------	-------------------------------

1. All schools have the ICT infrastructure in my district.

2. Government is ready to make ICT infrastructure available to schools.

3. The curriculum support ICT usage in learning Chemistry.

4. The timetable of the school permits the use of ICT in teaching Chemistry.

5. The work load of the Physical Science syllabus allows the use of ICT in learning.

6. Schools and teachers can get access to computer simulation software programmes that are compatible with the South African syllabus.

7. Learners can get access to computer simulation software programmes that are compatible with the South African syllabus.

8. I find it time consuming to use computer simulations in teaching Chemistry.

9. Learners get distracted by ICT during learning of Chemistry.

10. Learners cannot learn Chemistry with computer simulations on their own; they need help from the teacher.

11. Computers available in my school are enough for all learners in my classroom.

APPENDIX D: PILOT GROUP

TEST SCORES FOR THE PRE-TEST AND THE POST-TEST OF THE PILOT GROUP

	PRE-TEST		POST-TEST	
NO.	X_1	X_1^2	X_2	X_2^2
1	40	1600	46	2116
2	32	1024	36	1296
3	28	784	34	1156
4	36	1296	42	1764
5	44	1936	50	2500
6	38	1444	50	2500
7	38	1444	42	1764
8	32	1024	34	1156
9	28	784	28	784
10	38	1444	38	1444
11	28	784	50	2500
12	36	1296	42	1764
13	28	784	30	900
14	36	1296	42	1764
15	26	676	40	1600
16	32	1024	24	576
17	32	1024	40	1600
18	32	1024	34	1156
19	34	1156	26	676
20	24	576	34	1156
21	26	676	30	900
22	28	784	22	484
23	42	1764	42	1764
24	22	484	26	676
25	22	484	44	1936
26	38	1444	32	1024
27	36	1296	38	1444
28	34	1156	36	1296
29	30	900	34	1156
30	24	576	30	900
31	30	900	40	1600

	PRE-TEST		POST-TEST	
NO.	X_1	X_1^2	X_2	X_2^2
32	30	900	34	1156
33	30	900	36	1296
34	30	900	40	1600
35	28	784	34	1156
36	30	900	28	784
37	30	900	32	1024
38	26	676	42	1764
39	28	784	38	1444
40	32	1024	32	1024
41	32	1024	36	1296
42	28	784	16	256
43	40	1600	38	1444
44	28	784	28	784
45	28	784	26	676
46	34	1156	38	1444
47	26	676	32	1024
48	42	1764	42	1764
49	30	900	26	676
50	22	484	40	1600
51	16	256	28	784
52	28	784	40	1600
53	26	676	26	676
54	38	1444	44	1936
55	34	1156	28	784
56	28	784	18	324
57	26	676	34	1156
58	42	1764	28	784
59	40	1600	52	2704
60	24	576	28	784
61	46	2116	52	2704
62	24	576	36	1296

	PRE-TEST		POST-TEST	
NO.	X1	X1 2	X2	X2 2
63	24	576	28	784
64	34	1156	26	676
65	26	676	26	676
66	36	1296	44	1936
67	24	576	32	1024
68	28	784	20	400
69	32	1024	46	2116
70	34	1156	42	1764
71	28	784	32	1024
72	30	900	36	1296
73	26	676	36	1296
74	40	1600	32	1024
75	38	1444	34	1156
76	32	1024	26	676
77	24	576	30	900
78	30	900	42	1764
79	36	1296	28	784
80	44	1936	44	1936
81	32	1024	34	1156
82	30	900	38	1444
83	26	676	22	484
84	44	1936	40	1600
85	36	1296	38	1444
86	24	576	34	1156
87	38	1444	42	1764
88	32	1024	36	1296
89	40	1600	48	2304
90	28	784	24	576
91	40	1600	48	2304
92	32	1024	38	1444
TOTAL	2908	95280	3234	119300
AVERAGE		2049.032		2565.591

APPENDIX E: RELIABILITY COEFFICIENT

CALCULATING RELIABILITY COEFFICIENT FOR THE PILOT GROUP

MEAN FOR TEST 1:

No. of Learner	X_1	X_1^2
$N_1 = 92$	$\Sigma X_1 = 2908$	$\Sigma X_1^2 = 8456464$

$$\bar{x}_1 = \frac{\Sigma X_1}{n} = \frac{2908}{92} = \underline{\underline{31.61}}$$

THE STANDARD DEVIATION FOR TEST 1:

$$SS_1 = \Sigma X_1^2 - \frac{(\Sigma X_1)^2}{n} = 8456464 - \frac{(2908)^2}{92} = 8456464 - 91918.09 = 3361.91$$

$$SD_1 = \sqrt{\frac{SS_1}{n-1}} = \sqrt{\frac{3361.91}{92-1}} = \sqrt{\frac{3361.91}{91}} = \underline{\underline{6.08}}$$

THE KR – 21 FORMULA:

$$r_{\text{total test}} = \frac{K(SD^2) - \bar{x}(K - \bar{x})}{(SD^2)(K-1)}, \text{ where}$$

K = the number of items in the test.

SD = the standard deviation of the scores.

\bar{x} = the mean of the scores.

KR – 21 FOR TEST 1:

$$r_{\text{total test}_1} = \frac{K(SD_1^2) - \bar{x}_1(K - \bar{x}_1)}{(SD_1^2)(K-1)} = \frac{30(6.1^2) - 32(30 - 32)}{(6.1^2)(30-1)} = \frac{30(37) - 32(-2)}{37(29)} = \frac{1045}{1073} = \underline{\underline{0.97}}$$

MEAN FOR TEST 2:

No. of Learner	X_2	X_2^2
$N_2 = 92$	$\Sigma X_2 = 3234$	$\Sigma X_2^2 = 10458756$

$$\bar{x}_2 = \frac{\Sigma x_2}{n} = \frac{3234}{92} = \underline{\underline{35.15}}$$

THE STANDARD DEVIATION FOR TEST 2:

$$SS_2 = \Sigma x_2^2 - \frac{(\Sigma x_2)^2}{n} = 119300 - \frac{(3234)^2}{92} = 119300 - \frac{10458756}{92} = 119300 - 113682.13 = 5617.87$$

$$SD_2 = \sqrt{\frac{SS_2}{n-1}} = \sqrt{\frac{5617.87}{92-1}} = \sqrt{\frac{5617.87}{91}} = \underline{\underline{7.86}}$$

THE KR – 21 FORMULA:

$$r_{\text{total test}} = \frac{K(SD^2) - \bar{x}(K - \bar{x})}{(SD^2)(K-1)}, \text{ where}$$

K = the number of items in the test.

SD = the standard deviation of the scores.

\bar{x} = the mean of the scores.

KR – 21 FOR TEST 2:

$$r_{\text{total test}_2} = \frac{K(SD^2) - \bar{x}(K - \bar{x})}{(SD^2)(K-1)} = \frac{30(7.9^2) - 35(30 - 35)}{(7.9^2)(30-1)} = \frac{30(62) - 35(-5)}{62(29)} = \frac{1685}{1798} = \underline{\underline{0.94}}$$

APPENDIX F: TEST SCORES

THE TEST SCORES FOR THE PRE-TEST AND THE POST-TEST OF THE TWO GROUPS

CONTROL SCHOOL

	PRE-TEST		POST-TEST	
NO.	X_1	X_1^2	X_2	X_2^2
1	42	1764	50	2500
2	30	900	28	784
3	30	900	40	1600
4	30	900	36	1296
5	40	1600	38	1444
6	44	1936	46	2116
7	46	2116	48	2304
8	24	576	26	676
9	44	1936	48	2304
10	32	1024	37	1369
11	32	1024	39	1521
12	30	900	42	1764
13	38	1444	40	1600
14	28	784	30	900
15	42	1764	44	1936
16	44	1936	44	1936
17	34	1156	38	1444
18	42	1764	46	2116
19	26	676	24	576
20	42	1764	42	1764
21	40	1600	38	1444
22	26	676	38	1444
23	44	1936	44	1936
24	36	1296	34	1156
25	38	1444	40	1600
26	36	1296	34	1156
27	28	784	36	1296

	PRE-TEST		POST-TEST	
NO.	X_1	X_1^2	X_2	X_2^2
28	38	1444	46	2116
29	32	1024	38	1444
30	36	1296	38	1444
31	28	784	44	1936
32	32	1024	42	1764
33	34	1156	30	900
34	24	576	28	784
35	36	1296	40	1600
36	44	1936	48	2304
37	36	1296	36	1296
38	36	1296	32	1024
39	36	1296	42	1764
40	28	784	28	784
41	40	1600	50	2500
42	48	2304	48	2304
43	36	1296	36	1296
44	34	1156	34	1156
45	30	900	34	1156
46	30	900	34	1156
47	28	784	34	1156
48	36	1296	46	2116
49	34	1156	38	1444
50	38	1444	44	1936
51	16	256	32	1024
52	52	2704	56	3136
53	32	1024	38	1444
TOTAL	1862	67924	2066	82966
AVERAGE	35.13208		38.98113	

EXPERIMENTAL SCHOOL

	PRE-TEST		POST-TEST	
NO.	Y_1	Y_1^2	Y_2	Y_2^2
1	24	576	34	1156
2	32	1024	36	1296
3	30	900	32	1024
4	28	784	40	1600
5	26	676	38	1444
6	32	1024	40	1600
7	32	1024	42	1764
8	42	1764	56	3136
9	40	1600	48	2304
10	40	1600	40	1600
11	20	400	44	1936
12	42	1764	48	2304
13	34	1156	40	1600
14	48	2304	44	1936
15	32	1024	40	1600
16	40	1600	30	900
17	34	1156	32	1024
18	30	900	36	1296
19	22	484	46	2116
20	36	1296	40	1600
21	38	1444	44	1936
22	26	676	36	1296
23	24	576	36	1296
24	36	1296	46	2116
25	40	1600	46	2116
26	36	1296	30	900
27	40	1600	46	2116

	PRE-TEST		POST-TEST	
NO.	Y_1	Y_1^2	Y_2	Y_2^2
28	30	900	38	1444
29	32	1024	40	1600
30	34	1156	34	1156
31	32	1024	34	1156
32	38	1444	36	1296
33	28	784	36	1296
34	34	1156	22	484
35	28	784	34	1156
36	32	1024	40	1600
37	28	784	40	1600
38	42	1764	40	1600
39	42	1764	48	2304
40	40	1600	42	1764
41	26	676	42	1764
42	30	900	32	1024
43	40	1600	38	1444
44	34	1156	36	1296
45	32	1024	42	1764
46	42	1764	42	1764
47	44	1936	50	2500
48	30	900	40	1600
49	42	1764	52	2704
50	26	676	32	1024
51	34	1156	36	1296
52	46	2116	42	1764
TOTAL	1770	62420		83412
AVERAGE	34.03846		39.5769	