Effects of computer simulations on the teaching of atomic combinations to grade 11 physical science learners

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Abstract
In this study, the Effects of Computer Simulations on the teaching and learning of atomic combinations was investigated in the Tshwane North District. The study employed a quasi-experimental design involving two grade 11 physical science classes; one as an experimental (52) and the other as a control group (53). The learners were randomly distributed into these groups. For the purposes of this paper only question one; how Computer Simulations affect the learning of atomic combinations, has been discussed. Questions two and three do not form parts of the paper hence were not discussed. A 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 help answer research questions two and three which guided this study. The questionnaire testing how learners and teachers are familiar with the use of computers and if there are any hindrance's to its usage. The test instrument was administered as a pre-test and post-test. The experimental group received computer-assisted teaching and the control group was taught by traditional teaching methods on the same topics. Analyses of scores of the two groups in post-test were compared using SPSS independent t-test. The results are as follows; $t = 0.467$, $df = 103$, $p = 0.048$ and the Sig. (2-Tailed) value is 0.641. Since this value is greater than 0.05, it can be concluded that there is no statistically significant difference.
Key words: Computer Simulations, Atomic Combinations, Grade 11 Physical Science, Information and Communications Technology.

Purpose of the Study

In this research, the aim is to study the Effects of Computer Simulations on the teaching and learning of atomic combinations. 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.

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 learner more responsible for their own learning (Bransford, Brown, & Cocking, 2000), 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 did not obtain a satisfactory understanding of scientific concepts 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 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). Recently there has been interest shown in science education reform which stresses the need for integrating computer technologies into learning and teaching (Herman, 1996). This research seeks to use computer simulations to teach atomic combinations to grade 11 learners and to create an activity based 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. Atomic structure and the periodic table provide vital conceptual frameworks for building a foundation for learning chemistry. But abstract chemistry concepts 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. Also, teachers most at times 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. This is also supported by Stieff & Wilensky, 2003; Zoller, 1990. From the point of addressing issues of learning and understanding, some science education researchers have shown that technology-based learning can be of help. 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 Information and Communication Technology (ICT) in education can help to generally deepen understanding (Dede, 1998). This research however, wants to find out if computer simulations will have effect on teaching and learning with respect to Atomic combinations.

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, Jean Piaget 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 is the major theoretical perspectives which support Computer-Based Instruction (CBI) as a means of enhancing learners' learning; the most leading learning theory of the 1990s. 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 by the help of a teacher or a more capable peer. Activity theory incorporates notions of understanding, history, mediation, motivation, culture and community (Vygotsky 1978; Leont'ev 1981). It insists that human activity is mediated by tools in a broad sense (Kaptelinin & Nardi, 1997). In the model of an activity system below, 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 this study, using the classical meditational triangle, the subjects are the learners and the object (objective) is to learn about atomic combinations. The tools are the computer simulations and 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:

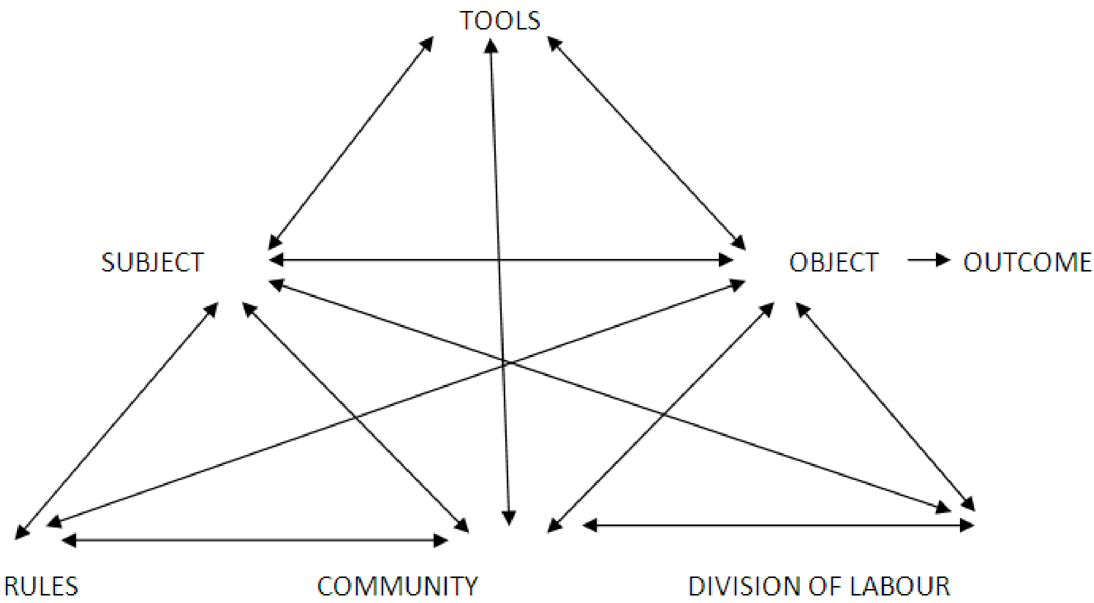

Figure 1: ACTIVITY SYSTEM

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 conceptions 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 seeks to ascertain if computer simulations can effectively affect learners learning atomic combinations in Chemistry.

Methodology

Research Design: The study made use of the Quasi-Experimental pre-test & post-test control group designs where learners' in existing grade 11 physical science classes were used.

Population of the Study

The population of this study was two grade 11 classes 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. The schools have computer laboratory facilities and are easily accessible by and to the researcher.

Sample and Sampling Technique

The sample looked at were grade 11 physical science learners as specified above. A class of the two classes was chosen at random to be an experimental group made up of 52 learners and the other, the control group which is also made up of 53 learners. In total a hundred and five learners took part in the study. The sample obtained was learners in existing grade 11 physical science classes. These learners were randomly placed in these classes. The learners wrote a pre-test to ascertain their knowledge base in the proposed topic (atomic combinations). After the intervention, the learners rewrote the pre-test as a post-test to access the effect of the intervention.

Instrumentation

Development of Instrument: The instrument used was an achievement test which was administered before and after the intended intervention. There were thirty items in the achievement test comprising multiple-choice question type. The test was developed around the learning areas under the topic atomic combinations (Atoms, Molecules and Compounds, Bond type, Molecular formulae and IUPAC naming). The test items were selected from the grade 11 textbooks popular with teachers and learners and past examination questions.

Validity and Reliability of Instrument

Validation: Content validation was carried out. 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 educators, 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 learners by their teachers in a different school as a pilot study. The pilot group is different from the sample of the study. This pilot group was determined based on the fact that they are Physical Science learners in grade 11 who have treated Atomic Combinations. It is a school with similar background as those used in the study. The aim of the researcher was to see if the research instruments were comprehensive, readable and answerable enough. 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 four to five weeks. For each group, control and experimental, two to three weeks was used for the data collection; pre-test; intervention; post-test, so that the learners will be prepared for the exercise psychologically. There were adequate numbers of test papers, for each individual learner as well as pencils and erasers. To ensure that all learners in the class returned their scripts, a class list was used each time when learners collected and returned the test papers.

Reliability

In addressing reliability of the study, a pilot group was determined as indicated above. The instruments were administered to the group for testing. The instruments was re-ordered and administered to the same class later in about 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 were used to calculate the coefficient of reliability using the above 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. 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 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 indeed. This helped to check for the consistency of the response from the learners.

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, models and computer simulations were used to teach on the same areas. The lessons were presented by the researcher. After the delivery of the lessons to the two groups by the researcher, the pre-test was administered as a post-test. This was to ensured 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. 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 weeks for each of the schools involved in the study.

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 used in this research it is only that the learners were randomly assigned to each group (control & 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-tests for the two groups, control and experimental were compared to see if there was any statistically significant difference at a selected probability level of 0.05 between the two groups. The researcher does not intend comparing both the pre-tests and post-tests concurrently of the two groups. Nevertheless, the mean scores of the pre-test and post-test of the two groups individually were compared to ascertain their knowledge gains after the lessons.

Results and discussions

Analysis of the pre-tests of the two groups: A pre-test was conducted before the treatment to establish whether or not the two groups were of the same ability in the topic atomic combinations before the treatment started. The scores of this test were also analysed and the result is indicated in tables 1. A t-test was calculated as shown in table 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 more than that of the experimental group (34.04) by one as indicated in table 1, there is no statistically significant difference in the achievement level of the two groups in the pre-test. This confirmed the equivalence of the two groups. Therefore it was evident that before the treatment the two groups were at the same level in the topic atomic combinations.

Analysis of post-tests of the two groups: The post-test scores for the two groups (experimental and control group) were analysed and the result is also presented in Tables 1 and 2 below. From table 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 your two conditions 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 your two conditions. 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 indicates that computer simulations did not influence significantly the performance of grade 11 learners in the said topic. All the same, the experimental group achieved slightly more with a mean mark of 39.58 compare to the control group who had a mean mark of 38.98 as shown in table 1 below. Furthermore, the experimental group were much more motivated and showed confidence and signs of interest (Sanger, 2000) when taught using computer simulations.

Table 1

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 2

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

Conclusions: The Effects of Computer Simulations on the teaching and learning of atomic combinations was investigated in this study. It was found out that the simulations did not significantly influence the performance of learners in the experimental group over the control group. This was also found in a study by Arowolo (2009) who used computer-assisted instruction to teach kinematics for a period of three weeks where the experimental group showed no significant improvement in their post-test results over that of the control group. Also Liu, Macmillan, & Timmons, (1998) found that there was no significant effect of computer integration on achievement or in learners' attitude toward computers after computer integration as well as Hsu and Thomas (2002) who conducted a research and 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.

References

Arowolo K.M. (2009). *The impact of information and communications technology (ICT) in the teaching and learning of kinematics in Grade 11 Physical Science*. Unpublished masters dissertation, of the University of the Witwatersrand, Johannesburg.

Bransford, J. D., Brown, A. L. and Cocking, R. R. (eds.) (2000). *How People Learn: Brain, Mind, Experience and School* (Washington, DC: National Academy Press).

Cobb, P. (1994). *Theories in mathematics learning and construction: A Personal view*. Paper symposium on trends and perspectives in mathematics education, Klagenfurt, Germany.

Cox, M. (2000). Information and communications technologies: their role and value for science education. In M. Monk & and J. Osborne, (Eds), *Good practice in science teaching – what research has to say.* Buckingham, England: Open University Press.

Dede, C. (1998) Learning about teaching and vice versa. Paper presented at Conference of Society for Information Technology in Education. Washington D.C., USA.

Gay, L.R., & Airasian, P. (2003). *Educational Research: Competencies for analysis and application* (7^{th} ed.). Columbus: Merrill, Prentice Hall.

Habraken, C. L. (1996). Perceptions of chemistry: Why is the common perception of chemistry, the most visual of sciences, so distorted. Journal of Science Education and Technology, 5, 193–201.

Herman, W. (1996). Assessing the impact of computer based learning in science. Journal of Research on Computing in Education, 28(4), 461–486.

Hsu Y. and Thomas, R. A. (2002). The impacts of a web-aided instructional simulation on science learning. *International Journal of Science Education,* 24(9), 955–979.

Jaber, W. (1997). A survey of factors which influence teachers' use of computer-based technology. Dissertation. Virginia Polytechnic Institute and State University. *Education, 36, 183-204.*

Jimoyiannis, A., and Komis, V. (2001). Computer simulations in physics teaching: a case study on students' understanding of trajectory motion. *Computers &* Kaptelinin, V., & Nardi, B. A. (1997). Activity Theory: Basic Concepts and Applications. Paper presented at the CHI 97, Atlanta.

Leont'ev, A.N. (1981). *Problems of the development of mind*. Moscow: Progress.

Liu, X., Macmillan, R., & Timmons, V. (1998). Integration of computers into the curriculum: How teachers may hinder students' uses of computers. *McGill Journal of Education, 33, 69*.

McMahon, M. (1997, December) Social Constructivism and the World Wide Web – A Paradigm for Learning. Paper presented at the ASCILITE conference. Perth, Australia.

Morgil, _I., Oskay, O¨ ., Yavuz, S., & Arda, S. (2003). The factors that affect computer assisted education implementations in the chemistry education and comparison of traditional and computer assisted education methods in redox subject. The Turkish Online Journal of Educational Technology, 2(4) (article 6).

Ozmen, H. (2008). The influence of computer-assisted instruction on students' conceptual understanding of chemical bonding and attitude toward chemistry: A case for Turkey. *Computers & Education* 51 (2008) 423–438.

Sanger M.J. (2000). Using particulate drawings to determine and improve students' conceptions of pure substances and mixtures. J Chem Educ 77:762-766.

Stieff, M., & Wilensky, U. (2003). Connected chemistry-incorporating interactive simulations into the chemistry classroom. Journal of Science Education and Technology, 12(3), 285–302.

Uden, L. (2007). Context design for mobile learning using activity theory. *International Journal of Mobile Learning and organization*, **1**(1), 81-102.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Williams R. (2006). The Young Child as Scientist: A Constructivist Approach to Early Childhoood Science Education (2nd edition) Allyn & Bacon.

Zoller, U. (1990). Students' misunderstandings and misconceptions in college freshman chemistry (general and organic). Journal of Research in Science Teaching, 27(10), 1053–1065.