

Implementing a Context-Based Approach in the Teaching of Genetics

M.M.M. Kazeni & G.O.M. Onwu

Department of Science, Mathematics and Technology Education, University of Pretoria
monde.kazeni@up.ac.za

Abstract

This study was concerned with a context-based approach to the development and implementation of genetics teaching materials for use at secondary school level, for learner motivation and improved performance. Recent surveys have reported worldwide decline in young people's interest in the study of science subjects and science-related courses, which ultimately poses the potential threat of reduced research activity, and in turn economic productivity. Learners' failure to see the relevance of science education to their lives could partly account for the loss of interest in the study of science. In this study, contexts identified by learners themselves as particularly interesting, relevant and accessible for studying genetics, were used to develop context-based materials for teaching genetics. The study adopted a mixed method research approach, in which the primary data collection techniques were quantitative in nature. A quasi-experimental non-equivalent pre-test/post-test control group design was used to compare the performance of learners who had been exposed to a context-based teaching approach with those exposed to traditional teaching approaches, in genetics, science inquiry, problem-solving, decision-making skills and attitude towards the study of life science. Qualitative data was used to augment and triangulate quantitative data for greater insight into an understanding of the results of the study. The study sample comprised 190 grade 11 learners and six life science educators. The findings of the study show that the context-based teaching approach was significantly better than traditional teaching approaches in enhancing overall learner performance. The educational implications of the study are discussed.

Key words: context-based teaching, traditional teaching, context, relevance, performance.

1.0 INTRODUCTION

In recent years, a discernible trend in science education worldwide has been the declining number of learners taking science-related courses and going into science-related careers (Centre for Education and Industry [CEI], 2009; European Industrial Research Management Association [EIRMA], 2009; Jenkins & Pell, 2006; The Institution of Engineering and Technology [IET], 2008). In South Africa for example, a demonstrably low percentage of all post-secondary education degrees are in mathematics, science or engineering. South Africa's ratio of scientists and engineers to the population stands at 3.3 per 1000 compared with 21.5 per 1000 and 71.1 per 1000 in the US and Japan respectively (NRF Report, 2005). Further, in comparison with non-science fields, such as business and management, and humanities and social sciences, the enrolment of South African learners in Science, Engineering and Technology (SET) in public higher education institutions has been consistently lower over the past decade (DoE: Education statistics 2000 -2009).

Continued decline in learners' uptake of science-related courses is likely to constrain the production of science graduates, which could eventually impact negatively on economic development, the quantity and quality of scientific research output, the capacity of

countries to innovate, manpower in science-related professions, and the creation of a scientifically literate citizenry (European Commission, 2007). Lack of progress in the stated areas could exacerbate the prevalence of social ills in society. These include lack of adequate water, enhanced poverty, crime, disease, un-employment, social strife, economic dependence on other nations, and many others, especially in developing countries (European Commission, 2007; UNESCO report, 2006).

The reasons for the declining uptake of science-related courses by learners are diverse and complex. However, several studies (Jenkins, 2006; Jenkins & Nelson, 2005; Osborne, Simon & Collins, 2003; Sjøberg & Schreiner, 2005) have reported an alarming decrease in learners' interest in the study of science related subjects world-wide. A review of literature on the status of science education in Africa, (Anderson, 2006; Sjøberg & Schreiner, 2005) shows that the majority of learners in African countries have a positive attitude towards the study of science. However, studies (TIMSS reports, 1995; 1999; 2003; 2007) reveal disturbingly high failure rates of African learners in science subjects. In the South African context, reports (Pouris, 1993; TIMSS report, 2003) on learners' attitude towards the study of science show that while learners have a positive attitude regarding the value of sciences in society, most of them tend to be apprehensive about their ability to succeed in science subjects and science-related careers. Existing literature (Centre for Development & Enterprise [CDE] report, 2010; 2007; Reddy, 2006; TIMSS reports, 1995; 1999; 2003) shows an abysmal performance of South African learners in science subjects, including life sciences, at school level. The apprehension towards the study of science and poor performance in science subjects could account for the low uptake of science related courses at tertiary level.

Life science has generally been assumed to be a 'softer' science, compared to physical science. However, researchers (Bahar, Johnston and Hansell, 1999; Okebukola & Jegede, 1989; Tekkaya, Özkan & Sungur, 2001) have demonstrated that several topics in life sciences, including genetics, present a challenge to both learners and educators in schools, resulting in poor performance in the subject. In South Africa, for instance, the performance of learners in life sciences has been as poor, and sometimes, worse than that in physical sciences for several years (DoE: Education statistics, 2000 - 2009). Life science is becoming increasingly important in the understanding of socio-scientific issues in our societies, such as diseases, environmental degradation, the genetic engineering of organisms, and many others. Learner motivation and improved performance in life sciences is therefore vital for empowering the youth to relate to these social issues, increasing manpower in life science related careers, as well as for creation of scientifically literate citizenry.

Part of the challenge of declining interest and poor performance in science could be a result of what has been variously described as *crisis of relevance* or *crisis of misalignment* - of science education provision failing to meet the needs of the learners and society, in a rapidly changing environment (Jenkins & Pell, 2006; Onwu, 2009; Onwu & Kyle 2010). Many studies (Schayegh, 2007; Schreiner & Sjøberg, 2004) have established that the majority of learners do not perceive the study of science as being of relevance to their lives. This perception of the study of science could partly account for the loss of interest and poor performance in science subjects in schools, which ultimately leads to a decline in learners' uptake of science-related courses at tertiary level.

The way science lessons are conducted might at least partly account for learners' perception of the study of science as irrelevant to their lives. Several researchers (Holton, 1992; King, 2007; Kyle, 2006; Onwu, 2009; Schwartz, 2006; The European commission, 2007; Van Aalsvoort, 2004; Onwu, 2000) have argued that there is firm evidence that links learner attitude and disposition towards science, to the way science is taught. It appears that the traditional way of teaching science as rote memorization of factual knowledge and mastery of abstract concepts (European Commission, 2007; Onwu & Stoffels, 2005; Osborne & Collins, 2001) has failed to excite and attract learners, as it portrays the study of science as irrelevant, difficult and boring (CEI, 2009; EIRMA, 2009; IET, 2008). Learners like to be able to relate science and scientific principles to their everyday life (Lubben, Campbell & Dlamini, 1996; Suela, Cyril & Said, 2010). In this regard, whatever extreme views that learners may have about the difficulty, or lack of relevance and accessibility of their science course content are somewhat moderated if the course is more relatable to their daily life experiences.

In an attempt to enhance the relevance of science education and to arouse learners' interest, a discernible trend in science curricula development in the past few decades has been the use of context-based teaching approaches, which involve the incorporation of learners' daily real life experiences and applications of science into science lessons (Bennett, 2003; Bennett & Holmann, 2002; Gilbert, 2006). Several researchers (Bloom & Harpin, 2003; Gutwill-Wise, 2001; Ramsden, 1997; 1992; Taasoobshirazi & Carr, 2008; Yager & Weild, 1999) have used contextualized teaching as a means of increasing interest and developing learners' understanding of scientific principles. The term 'contexts' has a variety of interpretations, including environmental, societal, health, personal, community, economic, technological and industrial applications of science (Bennett, 2003), which could be used for all intents and purposes to develop relevant curriculum materials.

A variety of aims have underpinned the development and use of context-based teaching approaches, including the need to improve learner performance in science subjects, motivate learners, encourage the uptake of science courses, and enhance higher order thinking skills. It would appear that the main driving force behind the development of context-based materials has been to enhance the relevance of science education so as to motivate learners in the study of science (Bennett, 2003). Interestingly, developers of context-based science curricula at various educational levels, especially at primary and secondary levels have almost consistently used relevance of contexts to learners, as perceived by educators and curriculum developers who are adults and 'experts' (and not the learners themselves) as the sole criterion for the selection of contexts (Bennett & Holman 2002; Osborne & Collins, 2001). Few studies, if any, are reported in the literature, which focus on discovering directly from the learners the contexts which they themselves find particularly relevant, accessible and interesting in the study of science topics at secondary level.

A possible consequence of the exclusion of learners from decisions about science teaching, including context-based teaching approaches, is the alienation of learners from the very science learning materials that are envisaged to motivate them. Therefore, in this study, a specific framework of context-based teaching approach was used, where a survey of science learners was initially conducted to determine contexts which the learners themselves identified as relevant, accessible and interesting for the study of genetics, a life science topic considered difficult to learn. The contexts determined by learners were used to develop curriculum materials for teaching genetics. The effectiveness of these materials in

enhancing learner achievement in genetics, science inquiry skills, problem-solving and decision-making ability, as well as learner attitude towards the study of life sciences was assessed.

2.0 THE STUDY

The study sought to develop and use a context-based framework for teaching genetics, and to assess its effectiveness in enhancing learner performance in genetics and life sciences as a subject. The genetics context-based teaching materials developed in the study were exposed to learners using a five-phase learning cycle, as described below.

2.1 Context-based approach used in the study

The context-based approach used in the study consisted of five phases, presented in the following order;

1. Introduction of context
2. Interrogation of the context
3. Introduction of content (concepts)
4. Linkage of concepts and the context
5. Assessment of learning

Phase 1: Introduction of context

During this phase, learners were provided with relevant and concrete situations (contexts) related to specific genetics concepts. These contexts were presented in the form of narratives, stories, demonstrations or plays about health issues, genetic dilemmas, or familiar social incidences. The following is an example of such narratives.

Mr. and Mrs. Sizwe have been married for twenty years, and they have four daughters, without any son. This situation worries Mr. Sizwe because according to his custom, having no son means that there will be nobody to take over as his heir when he dies. Mr. Sizwe decided to consult his elders about his situation, and they advised him to marry a second wife who could bear him a son. To his dismay, the second wife gave birth to a girl.

The criterion for the selection of contexts used in the narratives was that, they belonged to at least one of the three context categories identified by learners in the initial survey, namely; learners' personal lives, societal issues and environmental issues. The selected context(s) also had the following features. They:

- were based on learners' real life experiences or situations that are familiar to them (not abstract situations)
- had the potential to arouse learners' interest and/or empathy
- were contemporary issues and relevant to learners
- required high level reasoning skills (problem-solving, decision-making, analysis)
- were comprehensible to learners

Phase 2: Interrogation of context.

The second phase involved exploration of the introduced situations (contexts) by learners, through question and answer sessions, discussions, brainstorming, debates and problem-solving activities. For the example given above, learners worked in small groups to answer questions related to the situation, such as stated below.

1. Who is responsible for determining the sex of a child (the husband or wife)?
2. How is the sex of a child determined?
3. Why do some couples have girls or boys only? etc

This phase allowed learners to think about the context in order to identify what they already know about it, what they do not know, and to attempt to resolve and reason around emergent issues. The mostly cognitive activity in this phase helped to reveal learners' preconceptions, stimulate their thinking and curiosity about the issues under discussion, and to keep them alert and focussed on the lesson.

Phase 3: introduction of Content (Concepts)

The third phase involved presentation of relevant genetics content (concepts, ideas and principles) by the educator. Only content that was necessary for explaining, clarifying, solving or understanding the introduced context was taught. For the above given example, only concepts related to sex determination, such as, human karyogram, X and Y chromosomes, segregation during meiosis, gametogenesis, fertilization, etc., were taught for this particular context. This phase therefore provided learners with the genetics knowledge required when thinking and attempting to resolve or understand the context(s) under consideration. Some concepts were necessary for the understanding of different contexts within the unit. As a result, genetics concepts, principles and facts were re-visited again and again in the different themes of the unit, as required to understand the context being studied.

Phase 4: Linkage of content and context.

In the fourth phase, learners worked in small groups to make the necessary links between the content taught and the context under consideration. For instance, questions discussed during this phase, in the example given above included the following:

Having learnt the principles that govern sex determination, consider the issues addressed in phase 2 (context interrogation phase), and attempt to explain them again.

1. Do you still maintain the explanations and answers given earlier?
2. If your answer is yes, explain why you think your original explanations and answers are correct.
3. If your answer is no, why have you decided to change your original explanations and answers?
4. Do you have any questions which cannot be answered using the information provided?

The fourth phase therefore provided learners with an opportunity to evaluate and perhaps re-evaluate their initial thinking and decisions (as expressed in the interrogation phase). The activity of this phase encouraged learners to use rational and informed reasoning to try to explain and resolve the issues and questions under consideration. By attempting to link the learnt concepts to the contexts, learners were likely to ground themselves on reliable and valid genetics knowledge and construct their own meaning and understanding of genetics principles.

Phase 5: Assessment of learning.

In the final phase (the assessment of learning phase), learners were given tasks requiring the application of learnt concepts to novel situations. Class exercises, quizzes, problem-

solving tasks and tests were used in assessing learners' conceptual knowledge and skills ability. Examples of such applications of content to solve problems, with regard to the example given above, include the following:

1. Explain why some twins have the same sex, while others have difference sexes.
2. Your friend tells you that it is possible for a couple to decide whether to have a girl or a boy. What would you tell him or her?

The context-based approach described above, and traditional teaching approaches were compared in respect to their effectiveness in enhancing learner performance in genetics content knowledge, science inquiry skills, problem-solving and decision-making ability, and their attitude towards the study of life sciences. Traditional teaching approach, in the context of this study, refers to the usual teaching methods or approaches used by educators to teach genetics.

The study addressed the main research question of how learners exposed to a context-based teaching approach would differ from those exposed to traditional teaching approaches with regard to achievement in genetics content knowledge, science inquiry skills, problem-solving and decision-making ability, and their attitude towards the study of life sciences? Several null hypotheses based on this question were tested. Learners' and educators' views that could possibly account for differences in student performance, if any, were explored.

2.2 Research design

The study adopted a mixed research (QUAN/Qual) method, in which the primary data were quantitative, while qualitative data played a supportive role, to augment and triangulate some aspects of the quantitative data, and to provide more insight into an understanding of the results. The quantitative research component of the study used a quasi-experimental non-equivalent pre-test/post-test control group design (Campbell & Stanely, 1963), to compare the performance of learners who had been exposed to a context-based teaching approach and those exposed to usual teaching approaches, on attainment of genetics content knowledge, science inquiry skills, decision-making and problem-solving ability, as well as their attitude towards the study of life science.

2.3 Participants and method

The study was conducted in six (6) government schools in the Tshwane South educational district of the Gauteng province, in South Africa. Eight (8) life sciences educators from different schools that met the study criteria volunteered to participate in a workshop for implementing context-based teaching materials. At the end of the workshop, three educators were selected on merit, to teach genetics in their respective schools, using the context-based teaching approach. These schools, comprising eighty-seven (87) grade 11 learners, constituted the experimental group. Three (3) other schools comprising one hundred and three (103) grade11 learners were randomly selected from the qualifying schools, to constitute the control group. The participating learners had not studied the topic of genetics prior to the study.

In the design used in this study, pre-tests were administered to both the experimental and control groups. Thereafter, the experimental group was taught genetics for seven weeks using the developed context-based materials, while the control group was taught the same topic, over the same period of time using usual teaching methods (traditional teaching

approaches). After the intervention, post-tests were administered to both groups to assess learner performance on the same learning outcomes.

The instruments used to assess learner performance in the study included a Genetics Content Knowledge Test (GCKT), Test of Science Inquiry Skills (TOSIS), Decision-Making Ability Test (DMAT), Problem-Solving Ability Test (PSAT) and Life Science Attitude Questionnaire (LSAQ). Inferential statistic of Analysis of Variance (ANOVA) was used to compare the pre-test mean scores of the experimental and control groups, while Analysis of Covariance (ANCOVA), using pre-test scores as covariates, was used to assess the significance of any differences between the mean scores of the two groups, on the stated learning outcomes. In all statistical testing of hypotheses related to the research question, a p-value equal to or less than 0.05 ($\alpha \leq 0.05$) was considered statistically significant at 5% significance level.

After post-testing, fifty-eight (58) learners from the participating schools volunteered to take part in focus group interviews. Each focus group consisted of at least six learners, whose allocation to the focus groups was based on preference. The six educators who taught genetics to the experimental and control groups were also interviewed using semi-structured one-to-one interview.

2.4 Major findings

The quantitative results of the study are presented in Tables 1 and 2, below. Table 1 shows a summary of the descriptive (means scores and standard deviations - SD) and inferential (F-value and p-value) statistics for the pre-test and post-test results, for each of the learning outcomes (dependant variables) assessed in the study.

Table 1 Summary of pre-test and post-test descriptive and inferential statistics for genetics content knowledge, science inquiry skills, problem-solving ability, decision-making ability and attitude towards the study of life sciences.

Test	Group	Pre-tests					Post-test				
		N	Mean score	SD	F-value	P-value	N	Mean score	SD	F-value	P-value
GCKT	E	87	10.21	5.15	0.03	0.861	85	26.68	11.14	63.00	<0.0001 *
	C	101	10.35	5.31			93	15.46	7.60		
DMAT	E	87	58.32	23.62	3.19	0.0759	85	68.30	18.85	17.22	<0.0001 *
	C	94	52.23	22.25			86	54.70	24.79		
PSAT	E	87	29.69	21.31	0.09	0.7629	86	48.00	25.80	16.57	<0.0001 *
	C	96	30.63	20.51			88	34.06	19.53		
TOSIS	E	86	23.95	11.61	0.12	0.7296	80	28.92	10.74	3.44	0.0654

	C	99	23.38	10.75			86	25.41	13.61		
LSAQ	E	86	121.66	10.78	0.21	0.6504	77	127.96	9.98	25.04	<0.0001 *
	C	99	122.37	10.49			82	117.16	17.73		

Note: The total scores for GCKT, TOSIS, DMAT and PSAT were 100, and the total score for LSAQ was 150.

KEY: *Indicates a significant difference at $\alpha = 5\%$ significance level.

GCKT: Genetics Content Knowledge Test

LSAQ: Life sciences Attitude Questionnaire

DMAT: Decision-Making Ability Test

C: Control group

PSAT: Problem-Solving Ability Test

E: Experimental group

TOSIS: Test of Science Inquiry Skills

The results on Table 1 show no significant differences between pre-test mean scores of the control and experimental groups on all the learning outcomes assessed. On the other hand, the results show significant differences between post-test mean scores of the two groups on achievement in genetics content knowledge test (GCKT: $F [1,175] = 63.00$, p -value = <0.0001), decision-making ability test (DMAT: $F [1,168] = 17.22$, p -value = <0.0001), problem-solving ability test (PSAT: $F [1,171] = 16.57$, p -value = <0.0001), and life sciences attitude questionnaire (LSAQ: $F [1,156] = 25.04$, p -value = <0.0001), in favour of the experimental group. Comparison of post-test mean scores for overall science inquiry skills showed no significant difference between the performance of the two groups (TOSIS: $F = 3.44$, p -value = 0.0654 ; Table 1). However, assessment of specific science inquiry skills showed some discrepancies between the two groups (Table 2).

Table 2 below, shows that learners from the experimental group performed better than those from the control group on the ability to formulate hypotheses (T1: $F [1,163] = 33.21$, p -value = <0.000) and to draw conclusions from results (T5: $F [1,163] = 7.70$, p -value = 0.0062 ; Table 2). There was no significant difference between the two groups in their ability to identify variables (T2; $F [1,163] = 0.00$, $p = 0.9866$), design experiments (T3; $F [1,163] = 0.05$, $p = 0.8273$), and to draw graphs (T4; $F [1,163] = 0.54$, $p = 0.4642$; Table 2).

Table 2 Summary of pre-test and post-test descriptive and inferential statistics for specific components of Science Inquiry Skills (TOSIS: T1 to T5)

Component of inquiry skills	Group	PRE-TEST SCORES					POST-TEST SCORES				
		N	Mean score	SD	F-value	p-value	N	Mean score	SD	F-value	P-value
T1	E	86	3.6046	4.5930	2.80	0.0962	80	5.8971	2.3639	33.21	<0.0001*
	C	98	4.2857	2.7806			85	3.9085	2.0549		
T2	E	86	3.61492	3.6149	0.13	0.7222	80	4.1317	3.7123	0.00	0.9866
	C	98	4.79591	4.0562			86	4.1216	3.9994		
T3	E	86	5.6395	4.5242	1.94	0.1657	80	7.7157	6.8410	0.05	0.8273
	C	98	6.5816	4.6305			86	7.4736	7.3063		
T4	E	86	7.3255	6.0729	4.29	0.0398	80	5.8380	4.1643	0.54	0.4642
	C	98	5.3061	7.0277			86	6.5459	7.5401		
T5	E	86	2.7906	3.8043	0.06	0.8034	86	5.3860	4.7212	7.70	0.0062*
	C	98	2.6530	3.6752			79	3.4244	4.4233		

KEY:	*Indicates a significant difference at $\alpha = 5\%$ significance level.	
T1:	Ability to formulate hypotheses	T5: Ability to draw conclusions from results
T2:	Ability to identify variables	E: Experimental group
T3:	Ability to design experiments	C: Control group
T4:	Graphing skills	

The quantitative results suggest that the context-based teaching approach used in this study was significantly better than the traditional teaching approaches in enhancing learners' achievement in genetics, decision-making, problem-solving, hypotheses formulation ability and the ability to draw conclusions from results, and in improving their attitude towards the study of life sciences. However, there was no significant difference between the two teaching approaches in the enhancement of learners' overall science inquiry skills.

2.4.1 Qualitative results

Post-intervention focus-group interviews held with the experimental group revealed that learners enjoyed the study of genetics, and were very confident about their performance in the topic. They mostly attributed their enjoyment and good performance in genetics to the way the topic was taught, as evident in the following quotations from focus group interview protocols.

- Learner X: "If all educators taught us the way 'sir (*the educator*)' did, we would never fail any subject. I enjoyed looking back at my original ideas".
- Learner Y: "The nice thing about the lessons was that we talked about things that happen in our own homes. I now understand why my brother looks so different from all of us".
- Learner Z: "It was fun to learn genetics by using our own experiences. It just makes the study of genetics so easy and interesting. I am sure I have passed the test".

Individual interviews with educators who taught the experimental group showed that they were highly satisfied with their learners' participation during genetics lessons, and were of the opinion that their learners' performance in the post-tests would be good. The following quotations from the educators themselves attest to these assertions.

Educator A: "Learners were very excited during lessons, especially during phase 4. Sometimes it was quite difficult to control them, because they came up with so many questions and suggestions".

Educator B: "For the first time, I did not have to force my learners to talk. In fact, I had to control them most of the time. Everyone wanted to say something".

Educator C: "Learners who were taught using the new method really understood the lessons, because they were able to relate everything they did in class to what happens in real life. Once you tell them what happens in real life, and then teach them the relevant genetics concepts, it becomes easy for them to understand".

Focus group interview results involving the control group showed that learners also enjoyed the study of genetics. However, they were apprehensive about their performance in the topic, citing difficulty, profusion and diversity of genetics terms, and lack of practical activity in genetics lessons as possible reasons for poor performance in the topic. They also expressed a strong desire for exposure to real life situations related to genetics. These views are derived from the following quotations from the focus group interview protocols.

Learner Q: "Genetics was interesting, but when it comes to the assessments were fail, maybe it is because we get scared or panic".

Learner U: “Truly speaking the topic of genetics is wide, because it consists of many terms and principles, but it is interesting because it teaches us about things like how we are related to our ancestors and how we pass gene to future generations”.

Learner V: “If we could take trips to places where we can observe what really happens in genetics, then, maybe we could understand genetics better”.

Learner W: “I think that, if we can do practical activity in genetics, it will be easy to see and understand what is going on in genetics”.

Educators who taught the control group confirmed the interest in genetics declared by their learners, and acknowledged that learner performance in genetics was poor. The following are examples from educators’ comments.

Educator C: “Learners appear to be interested in the study of genetics, but I don’t understand why they perform poorly in assessments.”

Educator E: “Learners like genetics, because they become excited when we discuss issues in genetics, but they are too lazy to study, that’s why they fail.

The qualitative data provides support to the quantitative results, which suggests that compared with the traditional teaching approach, the context-based teaching materials and approach significantly enhanced learner performance on almost all learning outcomes. However, while the quantitative data showed a significant difference in the mean scores of the experimental and control groups on the attitude questionnaire, in favour of the experimental group, the values of these mean scores indicated that both the experimental and control groups had a positive attitude towards life sciences, which was confirmed by opinions from the post intervention interviews.

Commenting on the wide use of context-based approaches to science teaching, in the school settings studied, educators from the experimental group commended the approach, although they raised some concerns regarding time constraints and mental demands on the educator, in accomplishing all the five phases of the context-based teaching approach. They further surmised that the approach might present challenges to educators who are not well trained in context-based teaching. The educators also noted that these constraints could be overcome by way of thorough planning and training of educators who wish to use the approach.

3.0 CONCLUSION

Based on the findings of the study discussed in this paper, it has clearly been shown that the use of contextualized teaching has a profound effect on learner performance in school science. Although the results from the data suggest that learners from both the context-based and traditional teaching groups found genetics interesting, it was clear that interest alone did not always translate into improved performance. It may therefore be surmised that the different teaching approaches used could account for the performance differences of the experimental and control groups in the learning outcomes assessed. The context-based teaching approach has also been shown to be important for the development of skills and competencies that may enhance sustainability and social responsibility of science education. The enhancement of learners’ conceptual understanding of genetics, problem-solving and decision-making ability are not only important for learner achievement but are also necessary for the empowerment and emancipation of science learners (Kyle 2006,

Onwu & Kyle 2011) to be effective participants in discourses about science-based issues affecting society.

4.0 REFERENCES

- Anderson, I.K. (2006). *The Relevance of Science Education as seen by pupils in Ghanaian junior secondary schools*. A Thesis submitted in partial fulfilment of the requirements of the degree of Doctor of philosophy. Department of Mathematics and Science Education. University of the Western Cape, South Africa. Retrieved on April 23, 2009, from <http://www.ils.uio.no/english/rose/network/countries/uk-england/uk-england.html>. on
- Bahar, M., Johnston, A.H., & Hansell, M.H. (1999). Re-visiting Learning Difficulties in Biology. *Journal of Biological Education*, 33(2), 84-86.
- Beaton, A.E., Martin, M.O., Mullis, I.V.S., Gonzalez, T.A., Smith, T.A., & Kelly, A.L. (1996). *Science Achievement in the middle school years: IEA's Third International mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center. Boston College, USA. Retrieved on March 10, 2009, from <http://timss.bc.edu/timss1995i/TIMSSPDF/BSciAll.pdf>
- Bennett, J. (2003). *Teaching and Learning Science: A Guide to Recent Research and its Application*. New York, London: Continuum International Publishing group.
- Bennett, J., & Holman, J. (2002). Context-based approaches to the teaching of Chemistry: What are they and what are their effects?. In J.K. Gilbert, De Jong, O.Justi, R.Treagust, D.F., and Van Driel, J.H. (Eds), *Chemical Education: Towards Research-Based Practice* (pp.165-184). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Bloom, R.D.S., & Harpin, R.J. (2003). Integrating pharmacology topics in high school biology and chemistry classes improves performance. *Journal of Research in Science Teaching*, 40, 922–938.
- Campbell, D.T., & Stanely, J.C. (1963). *Experimental and Quasi-experimental Designs for Research: A Handbook for Research on Interactions*. Boston, MA: Houghton Mifflin.
- Centre for Development and Enterprise [CDE]. (2010). The maths and science performance of South Africa's public schools: Some lessons from the past decade. *CDE Research no. 1 (September 2010)*. CDE-Transmedit Place, 5 Eton Road, Parktown, Johannesburg, South Africa.
- Centre for Development and Enterprise [CDE]. (2007). Doubling for Growth: Addressing the Maths and Science Challenges in South Africa's Schools. *CDE-Research no. 15*. CDE- Parktown, Johannesburg.
- Centre for Education and Industry- CEI, (2009). *The Uptake of Plant Sciences in the UK*, University of Warwick, UK (February 2009). Retrieved on July 11, 2011, from <http://www2.warwick.ac.uk/fac/soc/cei/news/finalprintversiongatsbyplantsciencereport.pdf>,
- Department of Education [DoE: Education statistics]. (2000-2009). *Education Statistics in South Africa at a glance*. Pretoria: Government Printers, Retrieved on March 20, 2009, from www.education.gov.za
- European Industrial Research Management Association – EIRMA (2009) *Attracting young people into science and Technology*. Retrieved on July 11, 2011 from <http://www.eirma.org/eiq/017/pages/eiq-2009-017-0015.html>

- Gilbert, J.K. (2006). On the nature of "context" in Chemical Education. *International Journal of Science Education*, 28(9), 957-976.
- Gutwill-Wise, J. (2001). The impact of active and context-based learning in introductory chemistry courses: An early evaluation of the modular approach. *Journal of Chemical Education*, 77(5), 684-690.
- Holton, G. (1992). How to think about the 'anti-science' phenomenon. *Public Understanding of Science*, 1, 103-128.
- Jenkins, E., & Nelson, N. W. (2005). Important but not for me: students' attitudes toward secondary school science in England. *Research in Science & Technological Education*, 23(1), 41-57.
- Jenkins, E.W., & Pell, R.G. (2006). *The Relevance of Science Education Project (ROSE) in England: a summary of findings*. Centre for Studies in Science and Mathematics Education, University of Leeds. Retrieved on April 21, 2009, from <http://www.ils.uio.no/english/rose/network/countries/uk-england/uk-england.html>
- King, D.T. (2007). Teacher beliefs and constraints in implementing a Context-based Approach in Chemistry. *Teaching science: The Journal of the Australian Science Teachers Association*, 53, 1, 14-18.
- Kyle, W.C. Jr. (2006). The Road from Rio to Johannesburg: Where are the footpaths to/from Science Education? *International Journal of Science and Mathematics Education*, 4, 1-8.
- Lubben, F., Campbell, B., & Dlamini, B. (1996). Contextualizing science teaching in Swaziland: Some student reaction. *International Journal of Science Education*, 18(3), 311-320.
- Martin, M.O., Mullis, I.V.S., Foy, P., Olson, J.F., Erberber, E., Preuschoff, C., & Galia, J. (2008). *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College, USA. Retrieved on November 21, 2010, from <http://timss.bc.edu/TIMSS2007/sciencereport.html>
- Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., & Chrostowski, S.J. (2004). *TIMSS & PIRLS International Science report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center. Boston College, USA. Retrieved on March 10, 2009, from http://timss.bc.edu/PDF/t03_download/T03INTLSCIRPT.pdf
- Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., Gregory, K.D., Smith, A., Chrostowski, S.J., Garden, R.A., O'Connor, K.M. (2000). *TIMSS 1999 International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center. Boston College, USA. Retrieved on March 10, 2009, from http://timss.bc.edu/timss1999i/pdf/T99i_Sci_All.pdf
- NRF Annual Report (2004/05). *Annual Report of the National Research Foundation*. Pretoria, South Africa: Government Printers.
- Okebukola, P.A., & Jegede, O. (1989). Students' Anxiety towards, and Perception of Difficulty of some Biological Concepts under the Concept-mapping Heuristic. *Research in Science & Technology Education*, 7(1), 85-92.
- Onwu, G.O.M. (2000). How should we educate science teachers for a changing society? *South African Journal of Higher Education*, 14(3), 43-50.

- Onwu, G.O.M. (2009). Increasing the Social-Cultural Relevance of Science Education for Sustainable Development. *International Council of Associations for Science Education (ICASE- 1st quarter, 2009)*, 32-41.
- Onwu, G.O.M., & Kyle, W, C. Jr. (2011). Increasing the Socio-Cultural Relevance of Science Education for Sustainable Development. *African Journal of Research in Mathematics, Science and Technology Education*, 15(3), 5-26.
- Onwu, G.O.M., & Stoffels, N. (2005). Instructional functions in large, under-resourced science classes: Perspectives of South African teachers. *Perspectives in Education*, 23(3), 79- 91.
- Osborne, J., & Collins, S. (2001). Pupils' views on the role and value of the science curriculum: A focus group study. *International Journal of Science Education*, 23(5), 441-467.
- Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards Science: A review of the literature and its Implications. *International Journal of Science Education*, 25 (9), 1049-1079.
- Pouris, A. 1993. "Understanding and Appreciation of Science among South African Teenagers." *South African Journal of Science*. 83.
- Ramsden, J.M. (1992). 'If it is enjoyable, it's Science'. *School Science Review*, 73(265), 65-71.
- Ramsden, J.M. (1997). 'How does context-based approach influence understanding of key chemical ideas at 16+?'. *International Journal of Science Education*, 19(6), 697-710.
- Reddy, V. (2006). The state of mathematics and science education: schools are not equal. In S. Buhlungu (2006). *State of the nation: South Africa, 2005-2006*. Pretoria: HSRC Press.
- Rogan, J.M. (2000). Strawberries, cream and the implementation of curriculum 2005: towards a research agenda. *South African Journal of Education*, 20(2), 118-125.
- Schayegh, C. (2007). The social relevance of knowledge: Science and the formation of modern Iran, 1910s-1940s. *Middle Eastern Studies*, 43 (6), 941–960.
- Schwartz, A. T. (2006). 'Contextualized Chemistry Education: The American experience', *International Journal of Science Education*, 28(9), 977-998.
- Schreiner, C., & Sjøberg, S. (2004). Empowerment for Action ? How do young people relate to environmental challenges?. In S. Alsop (Eds.), *The affective dimension of cognition: Studies from Education in the Sciences* (pp 53-69). Dordrecht, The Netherlands: Kluwer.
- Sjøberg, S., & Schreiner, C. (2005). How do students in different cultures relate to science and technology? Results and perspectives from the project ROSE. *Asia Pacific Forum on Science Learning and Teaching*, 6, 1-16. Retrieved on January 31, 2010, from <http://folk.uio.no/sveinsj/APFLT-foreword-Sjoberg-schreiner.pdf>
- Suela, K., Cyril, J., & Said, H. (2010). *The Contexts Albanian students prefer to use in Mathematics and in relationship to contemporary matters in Albania*. Published in the proceedings of the eighteenth annual meeting of the Southern African Association for Research in Mathematics, Science, and Technology Education, held at the University of Kwazulu Natal, South Africa, 18-21 January, 2010.
- Taasoobshiraz, G., & Carr, M. (2008). A review and critique of context-based physics instruction and assessment. *Educational Research Review*, 3(2), 155-167.

- Tekkaya, C., Özkan, Ö., & Sungur, S. (2001). Biology concepts perceived as difficult by Turkish high school students. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 21, 145-150.
- The European Commission. (2007). *Science education now: A renewed pedagogy for the future of Europe*. Luxembourg, office for official publication of the European communities. Retrieved on October 12, 2009, from <http://ec.europa.eu/research/science-society/>
- The Institution of Engineering and Technology – IET, (2008). *Studying the STEM: What are the barriers? A Literature review of the choices students make*. Retrieved on July 11, 2011, from <http://www.theiet.org/factfiles/education/stem-report-page.cfm>
- United Nations Educational, Scientific and Cultural Organisation (2006): *Education for All (EFA) Global Monitoring Report 2006: Literacy for Life*. Paris, UNESCO. Retrieved on November 24, 2010, from <http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/efareport/reports/2006-literacy/>
- Van Aalsvoort, J. (2004). Logical positivism as a tool to analyze the problem of Chemistry's lack of relevance in secondary school chemical education. *International Journal of Science Education*, 26 (9), 1151–1168.
- Yager, R.E., & Weld, J.D. (1999). Scope, sequence and coordination: The Iowa project, a national reform effort in the USA. *International Journal of Science Education*, 21, 169-194.