

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter presents a discussion of the results of the study. The first section involves a discussion of the relative effectiveness of context-based and traditional teaching approaches in enhancing learner performance. The second section looks at the interactive influences of gender and cognitive preferences on the attainment of the learning outcomes. Finally, the context-based teaching approach that was developed in the study is evaluated.

5.2 EFFECT OF CONTEXT-BASED AND TRADITIONAL TEACHING APPROACHES ON LEARNER PERFORMANCE

The first research question sought to assess the relative effectiveness of context-based and traditional teaching approaches in enhancing learner performance. The results from analysis of covariance (ANCOVA) of post-test mean scores of the experimental and control groups showed that the experimental group performed significantly better than the control group in genetics content knowledge, problem-solving ability and decision-making ability, and had a more positive attitude towards the study of life sciences. No significant difference was observed between the experimental and control groups in the acquisition of overall integrated science inquiry skills. However, when specific science inquiry skills were analyzed separately, results showed that the experimental group performed significantly better than the control group in the ability to formulate hypotheses and to draw conclusions from results. These results are discussed in detail in subsequent sections.

5.2.1 Learners' content knowledge of genetics

Previous studies on the effect of context-based approaches to the teaching of science (Barber, 2001; Barker & Millar, 1996; Bennett & Holmann, 2002; Ramsden, 1998, 1997, 1992; Taasobshirazi & Carr, 2008) have reported inconclusive results or non-significant differences between the conceptual knowledge of learners exposed to context-based teaching approaches and those exposed to traditional approaches, even though a few other studies (Bloom & Harpin, 2003; Gut-Wise,

2001; Yager & Weld, 1999) showed improvements in the conceptual understanding of learners exposed to context-based approaches.

In this study, learners who experienced the context-based approach showed a significantly better content knowledge of genetics than those who were taught according to the usual traditional teaching methods (Experimental $F=63.00$; $p < 0.001$, table 4.1). The question arises as to what could account for the significant difference in learner performance in this particular study, especially since the competence of the two groups in genetics content knowledge was approximately the same before the intervention (table 4.1).

Comments from participating learners and educators suggest that differences in the performance of the two groups, after the intervention is likely to have derived from the methods used to teach genetics. Participants from the experimental group contend that the use of familiar contexts, to which learners could relate, and the use of minds-on and hands-on learning activities, as well as the linkage of content and contexts, were possible determinants of the enhanced performance of the experimental group as discussed below.

The contexts used to develop the context-based materials were determined by the learners themselves. Hence the materials were probably more familiar and relatable to learners than those used in previous context-based materials. The relevance of the selected contexts to the daily lives of the learners from the experimental group is likely to have motivated them to study genetics, as is evident from learners' views in these quotations.

ES68 It was fun to learn genetics using our own experiences. It just makes genetics so easy. I am sure I have passed the test.

ES51 The study of genetics was easy because we were able to link it to what happens in our homes.

The use of contexts selected by learners could have negated some of the difficulties usually experienced by learners in contextualized learning (DeJong, 2008; Pilot & Bulte, 2006). The educational benefits of involving learners in decisions about the development of curriculum materials, for familiarity and relevance of the materials, have been acknowledged by researchers (Cox et al, 2009; Osborne & Collins, 2001).

The control group that was taught using traditional approaches did not seem to be familiar and be able to relate with the learning materials, as evident from the following comments from the group.

- CS181 Some educators start teaching genetics without us knowing where it comes from, where it is situated and how it affects us.
- CS132 What makes it difficult is that we can't really see the things which we learn about.
- CS130 It (*genetics*) can be relevant if we talk about things which we can see, not just things we imagine in our minds.

Learners' inability to relate with the learning materials was probably a result of the fact that educators mainly used materials that were mostly predetermined by national curriculum developers and those found in textbooks. None of the educators who taught the control group indicated any involvement of learners in decisions concerning the teaching and learning materials. Neither was such a practice observed by the researcher during the study. Similarly, most of the existing contexts-based materials are developed from contexts selected solely by curriculum developers without involving the learners (Bennett & Holmann, 2002), as pointed out in sections 2.2.2.4 and 2.2.2.6. The exclusion of learners' views during material development could make the materials inaccessible to them.

The other element of the developed materials and approach that could have enhanced learner performance was the use of narratives based on real-life (authentic) situations, at the beginning of each lesson, which is consistent with Herbart's model for effective educational instruction, and constructivism. These teaching and learning models promote the commencement of lessons with what learners have experienced and they already know. The use of real-life narratives could have made the significance of studying genetics more explicit to the learners and thereby enabling them to construct knowledge. It could also have improved learners' attitudes towards the study of genetics, and made them want to learn more, and hence perform well in the topic. Learners' appreciation of the materials is implied in these quotations from the experimental group interview protocols:

- ES74 The nice thing about the lessons was that we were talking about things that happen in our homes. I now understand why my brother looks so different from all of us.
- ES60 If the things we learn are put to us as stories, it becomes easier to understand, rather than just giving us past questions, which we do not know how they relate to our lives.

Educators who taught the experimental group expressed similar sentiments about the use of real-life narratives in teaching genetics:

- ET1 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.
- ET3 Once you tell them what happens in real life, and then teach them the relevant genetics concepts, it becomes easier for them to understand.
- ET2 The teaching approach used in this programme turned out to be an exciting and interesting experience to learners. This is because situations and problems which relate to their everyday lives were used.

Comments from the control group on the other hand show that learners found some aspects of genetics difficult to understand. They cited the abstractness of concepts, the profusion of genetics terms, insufficient study time and educator-centred memory-oriented teaching approaches as possible reasons. These quotations from the control group interview protocols attest to these observations:

- CS102 Genetics is challenging because some of us do not understand what it is based on.
- CS199 Genetics is difficult because it is just rules and terms, which are difficult to understand.
- CS131 What makes it difficult is that we can't really see the things which we learn about.

Several researchers (Dogru-Atay & Tekkaya, 2008; Ibanez-Orcajo & Martinez-Aznar, 2005; Lewis & Kattman, 2004) have identified issues similar to those cited by learners from the control group: misconceptions in genetics; domain specific vocabulary and terminology in genetics; and perceived irrelevance to learners' daily lives, as possible reasons for poor learner performance in genetics.

Educators from the control and experimental groups admitted that in traditional approaches to the teaching of genetics, scientific concepts are rarely clearly explained and/or linked to real-life situations. These assertions are derived from educators' comments, such as those stated in the quotations below.

- ET1 Most educators do not usually link their lessons to issues happening outside the classroom. They rush to finish the syllabus by just presenting theory. In the end, the learners do not understand anything. That's why we have high failure rates.
- CT5 At times what makes learners get lost during the study of genetics is the way educators present the lessons as abstract concepts.

The five-phase learning cycle used to implement the context-based materials involved interrogating the contexts before exposing learners to relevant content, linking content and contexts, and applying learned content to novel situations, as suggested in Herbart' model for effective instruction. These elements created opportunities for learners to discuss, explain, and argue about real-life issues. The mental engagement allowed learners to examine the adequacy of their prior knowledge and beliefs (or preconceptions), and forced them to test these preconceptions against the content they had learned. According to educational theorists such as Dewey, Piaget, and von Glasersfeld, this intellectual engagement is likely to enhance the construction of knowledge (Abraham & Renner, 1986; Bybee, et al., 2006; von Glasersfeld, 1989). The role played by these cerebral activities in enhancing conceptual understanding was acknowledged by learners, as is evident in the experimental group's interview protocols:

- ES57 When we learned genetics, our educator allowed us to give our views, but with the other classes, we are not given an opportunity to say what we think.
- ES82 In other [usual] classes, there is no interaction between us and the educators, but here we are allowed to say what we think, even to argue with others or disagree with the educator.
- ES16 The way our educator taught us made the study of genetics easy. We talked about things that happen to us, so it was easy to understand. I especially enjoyed the part on diseases and the inheritance of features from our parents.

Educators who taught the experimental group echoed their learners' views in the following statements from their interviews:

- ET2 One outstanding aspect of the new approach is that the learners become very active during lessons, and therefore the learners understood the lessons better.
- ET3 For the first time, I did not have to force my learners to talk. In fact I had to control them at times. Everyone wanted to say something.
- ET3 The involvement of learners in the lessons made them feel appreciated, because they felt that the little they knew from home was integrated in the lessons.

Learners' active participation in lessons could have helped educators and learners to identify learners' alternative frameworks of pre-conceptions, which would then have been addressed in the content introduction phase. Contemporary research in cognitive science has shown that eliciting learners' prior knowledge and experiences is a necessary component of the learning process (Eisenkraft, 2003). Comments

from the experimental group learners' and educators' interviews reveal the importance of giving learners an opportunity to express their views before introducing content (scientific concepts):

- ES42 The discussions made me realize the myths which I had. By studying genetics, I managed to know the truth.
- ET3 What is good is that during the information phase, you have the opportunity to explain, and emphasize those issues where you noted the misconceptions.
- ET1 What I liked is that, during the content introduction phase, when you 'touch' on issues where learners had alternative conceptions, they would ask for clarification.

Stakeholders in traditional science education seem to assume that curriculum statements and textbooks contain sufficient information to develop learners intellectually and socially. Because of this assumption, educators and learners are expected to go over these materials and adopt them without question. Unfortunately, in an attempt to internalize curriculum and textbook information, the majority of learners end up memorizing concepts in order to pass examinations, without understanding them in depth (Taasobshirazi & Carr, 2008). This transmitter and passive recipient view of science education seems to have been the case in the control group, as suggested by comments from learners and educators from the group:

- CS131 We want to be involved in the lessons. Our educators talk and talk and talk, and we get bored, and at times feel sleepy.
- CS126 Genetics is difficult because we do not understand it, and the educators don't allow us to ask too many questions.

An educator who taught the control group acknowledged the possibility of instructional shortcomings about the traditional ways of teaching genetics in these statements:

- CS4 I think the way we teach genetics is limited to the sense of hearing. Our learners are not good at exploring issues on their own. They [learners] are very much reliant on the educator.
- CS4 I can't pick up exactly where the problem lies. It's probably the way we teach genetics or the types of resources that we use, because we normally use the chalkboard, posters, textbooks, and old models, and they don't seem to be effective in enhancing learners' achievement in genetics.

There seems to be a problem of educator-centred teaching in the traditional genetics classes. Comments from the control group appear to suggest that learners and educators blame each other for the lack of learner involvement in the lessons.

Further, the five-phase learning cycle used in the study emphasized practical activity, such as experiments and simulations, during the concept introduction phase. These activities are also common in the BSCS 5E learning cycle model (Bybee, et al., 2006), which has been effective in improving conceptual understanding in Biological sciences. The hands-on activities could have enhanced learners' enjoyment of genetics lessons, and in turn motivated them to study and try to comprehend genetics concepts, as indicated in these comments from learners who participated in the experimental group:

- ES65 I enjoyed the practical activities because they were about things that we see and that we hear from people.
- ES82 I think the practical activities helped me to understand the concepts better.
- ES64 The method used to teach genetics in this project was more practical, but other educators teach us theory only, which we don't understand.

Over the years, researchers (Hodson, 1993; Hofstein & Lunetta, 2004; Tobin, 1990) have noted that practical work enhances conceptual understanding in science. However, learners taught using traditional teaching methods are rarely involved in practical activity, especially in poor rural schools (Barmby et al., 2008; EC, 2007; Lyons, 2006; OECD, 2006; Onwu & Stoffels, 2005). When practical activity is used, learners often follow a 'cookbook' approach to experimentation (EC, 2007; Kang & Wallace, 2005; Lyons, 2006; OECD, 2006). It seems that practical activities were uncommon in the traditional approaches used to teach the control group in this study, as implied in these quotations from the group:

- CS112 The problem is that we do not do any practical activities in genetics. We would like to do practical activities so that we may understand genetics.
- CS141 We should be using microscopes to see what really happens in the cells.

Lack of practical activity in the traditional approaches to teaching genetics seems to derive from educators' lack of knowledge of relevant experiments that could be

conducted in genetics, and non-availability of materials for practical activities, as confessed by some of the participating educators during their interviews.

- ET2 Learners (from the experimental group) enjoyed the practical activities a lot. They could easily see the processes that are explained in theory. Frankly, I did not know that there were such interesting practical activities in genetics.
- CT6 I think practical activities can help to clarify the theory, but the problem is that, there are very few practical activities in genetics, and the materials are expensive, so we end up teaching the theory.
- ET3 I did not know that one could conduct interesting experiments in genetics. (*Previously*) It was very difficult to come up with genetics experiments which learners could be interested in, and which made sense. This method of teaching is really good.

Finally, the five-phase learning cycle introduced genetics content to learners in small manageable amounts (drip feed). Content delivered in small amounts could have reduced the load on learners' working memory. In addition, genetics concepts were revisited again and again in the various themes of the developed materials, which could have familiarized the learners with those concepts and increased the depth of mental processing. The drip feed manner of introducing content and the subsequent re-visiting of the content in different contexts is characteristic of many large-scale context-based materials, such as developed in Salters Projects (Bennett & Lubben, 2006), *Chemie in Kontext* (Parchmann, et al, 2006), and *ChemCom* (ACS, 2002) (See section 2.2.2.4). Some researchers (Bennett, 2003; Hung, 2006) affirm that introducing content in small quantities and revisiting it can enhance learners' conceptual understanding.

In sum, the findings of this study suggest that the use of contexts that are familiar and relatable to learners and the use of a five-phase learning cycle significantly enhanced learners' understanding of genetics concepts and the development of higher-order thinking skills. The efficacy of the five-phase learning cycle in enhancing learner performance is in consonance with findings from previous studies (Barman, Barman & Miller, 1996; Musheno & Lawson, 1999; Purser & Renner, 1983; Saunders & Shepardson, 1987), which showed that the use of a learning cycle enhances conceptual understanding. On the other hand, traditional ways of teaching genetics, which usually constitute the transmission of abstract information and which seldom incorporate minds-on and hands-on activities could account for the control group's overall poor performance in genetics.

5.2.2 Skills development

The higher-order thinking skills assessed in this study include integrated science inquiry skills, decision-making and problem-solving ability. The performance of learners in these skills is discussed in the succeeding sections.

5.2.2.1 *Integrated science inquiry skills*

Learners' competence in the integrated science inquiry skills of hypotheses formulation, identification of variables, experimental design, graphing, and data interpretation (ability to draw conclusions from results) was assessed. The results showed no significant differences between the control and experimental groups in their competence in overall science inquiry skills. However, a comparison of learners' performance in specific inquiry skills showed that the experimental group were significantly more competent than the control group in hypotheses formulation and the ability to draw conclusions from results.

The enhanced competence of the experimental group in formulating hypotheses and drawing conclusions from data probably resulted from learners' involvement in lesson activities that required them to engage in practical work and in discussions involving making predictions and providing explanations for science-related phenomena. For example, in a lesson about genetic counselling, decisions and ethics (appendix VI, unit 9.5), learners were required to make predictions and provide explanations, based on the information provided, as shown in the following example:

Claassen and Susan got married recently, and both have brothers who have cystic fibrosis (CF). Susan is now pregnant. Genetic tests show that Claassen and Susan are both carriers of the CF trait, and that the embryo is homozygous for the CF trait.

- (a) Given the knowledge of the embryo's genotype, what would you advise Susan to do about the pregnancy?
- (b) If your friends disagree with your advice to Susan, how may you defend your views?
- (c) What moral problems should they consider in making decisions about the embryo?

Questions such as those in the example (above) engaged learners in mental activity that required them to reason in terms of 'if ..., then ...' statements, which characterize hypothesis formulation. Learners were also required to provide

explanations for their suggestions and assumptions in light of learned information. These activities are meant to allow learners to have a deeper understanding of the phenomenon being studied (Bybee, et al. 2006; Eisenkraft, 2003). Such activity could have provided practice in drawing conclusions from results. These comments from the educators who taught the experimental groups attest to the involvement of learners in the described activity:

- ET2. The lessons highlighted situations and problems, and then provided explanations and possible solutions as they unfold in the various stages.
- ET3. Probing learners to give you what they understand about the topic makes them to think broadly. It therefore increases their thinking capacity, and makes them want to know more.

The ability of context-based teaching approaches to enhance certain science inquiry skills was shown by other researchers (Wierstra, 1984; Yager & Weld, 1999), who found considerably more inquiry learning and creativity in context-based than in control (traditional) classes.

In this study, the control group did not seem to have sufficient practice in activities that required them to make predictive statements and to provide explanations for socio-scientific issues. Learners tended to participate in lessons as passive recipients of knowledge, as indicated in the quotations below from learners who participated in the control group:

- CS167 They [educators] should use practical activities and examples which should include things like diseases that are caused by genetics. It will be easier to understand, because we would be able to apply what they teach us to our life.
- CS131 We want to be involved in the lessons. Our educators talk and talk and talk, and we get bored, and at times feel sleepy.
- CS167 Some learners learn by cramming [memorization] without interest, and without thinking about what they have crammed. They just want to pass the examination. They don't think about why these things happen.

The lack of significant differences between the performances of the experimental and control groups in the inquiry skills of identification of variables, experimental design and graphing could mean that these skills are acquired from the usual practical activities that are used to teach science in traditional classes, and that the context-based approach used in this study did not emphasize the development of these skills. Hence the context-based materials and approach did not have an advantage over traditional approaches in the attainment of the stated skills.

5.2.2.2 *Decision-making ability*

One of the hypotheses that were tested in this study was whether there would be any significant differences in the decision-making ability of learners in the control and the experimental groups. The experimental group showed significantly higher decision-making ability than the control group. The difference in decision-making ability of the two groups might have resulted from the fact that the activities in the context-based materials and approaches often required learners to make decisions about real-life situations, during context interrogation and when linking content to contexts.

There seems to be a supposition in science educational systems that exposing learners to curriculum materials automatically enhances the development of higher-order thinking skills which are crucial to contemporary life, such as decision-making ability. According to Aikenhead (1980), decision-making techniques and wisdom do not develop sufficiently in learners unless they constitute an explicit content of science curricula and examinations. However, the majority of science curricula do not contain materials that clearly teach decision-making skills. The South African life sciences curriculum for instance does not make explicit provisions for teaching decision-making techniques (DoE, 2008). It is therefore understandable that educators do not necessarily see the need to teach and emphasize such skills.

Science lessons tend to place more emphasis on acquiring conceptual knowledge, with little room for developing decision-making skills, because this is what is usually examined. Descriptions of typical genetics lessons by educators from the control group suggest that there were no explicit attempts to involve learners in activities that would allow them to practise decision-making techniques during lessons.

CT4 I normally teach genetics lessons by giving an introduction, involving some background to the lesson, and then I speak more about the lesson and give them content from the textbook, and then some exercises to do.

CT6 I usually start with a mind capture, like something that happened somewhere, to capture their (*learners*) attention. Then I teach them the concepts, and give them an assessment to see if they have followed the lesson.

In the experimental group, the context-based materials and approach frequently engaged learners in tasks that required them to explore problems, evaluate options, and make valid judgments on issues. Involvement in these mental activities

demonstrated to learners how knowledge of science content guides decision-making in contemporary life, and provided practice in decision-making.

5.2.2.3 *Problem-solving ability*

Another learning outcome assessed in the study was competence in problem solving. A comparison of learner competence in problem solving showed that the experimental group were significantly better than the control group. The enhanced competence in the experimental group could once again be related to the nature of the tasks in the materials, which required learners to solve real-life problems.

The context-based materials developed in this study involved tasks that challenged learners' intellect and motivated them to assess problems, reason around them, and use available information to seek solutions (see appendix VI). The extensive use of problem-solving activities in the experimental group probably contributed to the enhanced performance of this group in the PSAT, as suggested by one of the educators from the experimental group:

- ET2 What I really like about this new approach is that it encourages teamwork, develops problem-solving skills, communication skills, tolerance and understanding of diverse cultures.
- ET2 The lessons highlighted situations and problems, and then provided explanations and possible solutions as they unfolded in the various stages.

In summary, it appears that the teaching materials developed in this study improved learners' decision-making and problem-solving abilities, and enhanced the development of some science inquiry skills. The emphasis on learner- and activity-centred teaching, as well as discussions involving real-life issues, seems to have contributed significantly to improved higher-order thinking skills in the experimental group. The control group seemed to lack exposure to these activities and hence performed poorly in inquiry, decision-making and problem-solving assessments.

5.2.3 *Attitude towards the study of life sciences*

The study sought to determine learners' attitudes towards the study of life sciences. Comparisons of learners' overall attitudes showed that the experimental and the control groups had positive attitudes towards the study of life sciences before and

after the intervention. However, after the intervention, the post-test mean score of the experimental group was significantly higher than that of the control group. The results imply that while the overall attitudes of the experimental group towards the study of life sciences improved after the intervention, those of the control group were shown to be less positive (table 4.7 (b)). The enhanced attitudes of learners exposed to the materials developed in this study corroborate earlier findings (Ramsden, 1998, 1992; Reid & Skryabina, 2002; Yager & Weld, 1999) that context-based teaching approaches have a motivational effect on learners.

While it is acknowledged that attitude towards any school subject can be affected by a number of factors – such as ability, disposition, the quality of teaching, and learning environment – the control group's poor performance and their discontentment with the teaching approaches, even though they found the study of genetics interesting, could have influenced their attitude towards the study of genetics and life sciences as a subject. This supposition is drawn from these comments from the control group's interview protocols:

- CS97 Some of our educators just read from the textbook or give us questions from past examination papers, so we don't understand what is going on.
- CS188 The educators are the ones that make the study of genetics difficult, because most of them pretend to know genetics, but just follow what is written in textbooks, and they do not help us understand what is going on.

Conversely, the significant improvement in the attitudes of the experimental group could be attributed to their appreciation of the teaching approach, and their anticipated improved performance in the post-tests, as indicated in these comments:

- ES 34 Because of the way we were taught genetics, I am now interested in genetics, because it helped me to understand many things in life, such as how we happen to look alike with our brothers and sisters.
- ES 3 When I wrote the first test (pre-test), it was difficult, but after studying genetics, I felt more excited, and it became easy. I think I passed the second test (post-test).
- ES77 Everything about the topic was perfect; the practical activities and the stories made the topic fun.

Interestingly, inspection of post-intervention mean scores on items under various attitude categories (see table 4.8) revealed that the experimental group scored significantly higher than the control group on items from the following attitude categories: interest in the study of genetics as a topic (OA1); life sciences as a

subject (OA4, OA15, OA16, OA19, OA26, OA28, and OA29); and learners' perception of life sciences/genetics lessons (OA14, OA18, and OA20). This observation provides some support that learners from the experimental group found genetics lessons fun and comprehensible.

The lack of significant differences in the attitudes of learners from the experimental and control groups in the attitude categories of 'the application of life sciences to everyday life and 'the importance of studying life sciences for the enhancement of career prospects' suggests that learners from both groups were equally aware of, and valued the applications of life sciences to everyday life and the importance of studying life sciences in related professions.

Further, both the experimental and control groups claim to have interest in the study of life sciences (section 4.3.1.4) in spite of the discrepancies in their achievement in the genetics content test. It appears that interest and attitude alone might not have been necessarily determinants of achievement, although they could have motivated learners in the study of life sciences. Other workers (Belt, Leisvik, Hyde, & Overton, 2005; Campbell et al., 2000; Ramsden, 1992) have found that learners' interest and enjoyment (interest) of the study of science in context did not always translate into increased achievement. What is perhaps clear is that the teaching approaches used to instruct the experimental and control groups might explain the differences in the achievement of the two groups.

In concluding, the use of contexts selected by learners to develop context-based materials and the implementation of the materials using the five-phase learning cycle seem to have played significant roles in enhancing learner performance as evident in the following comments by learners from the experimental group.

ES48 The method we used to learn genetics should be used in other topics in life sciences and other science subjects, not just in genetics, so that we may understand what we learn.

ES44 The genetics programme that we did should be compulsory so that everyone can benefit from it, because those who missed the programme are disadvantaged.

It appears that the developed approach was also beneficial to the educators who implemented it, which in consequence improved their learners' performance, as stated in the comments below, from educator interviews.

- ET3 I would like to mention that the context-based approach is also helpful to the educator. It is a fact that most educators do not understand what they teach. This approach forces educators to understand what they teach because they know that the learners are likely to ask questions which they might not know how to answer.
- ET2 Genetics topics usually pose a lot of teaching challenges for educators and comprehension difficulties for learners, but the teaching method used in this programme made it easier for learners to understand.

It is acknowledged that the traditional ways of teaching science could be effective in enhancing learner performance. However, the results of this study show that lack of active learner involvement in hands-on and minds-on learning and of exposure to problem-solving and decision-making opportunities had a negative impact on the performance of the control group. These features of traditional teaching were also identified by Mji and Makgatho (2006) as some of the factors associated with South African high school learners' poor performance in science and mathematics.

5.3 INTERACTIVE INFLUENCES OF GENDER AND COGNITIVE PREFERENCES AND TREATMENT ON LEARNER PERFORMANCE

The second research question of the study sought to assess the interactive influences of gender and cognitive preferences, and the instructional approaches on learner performance. The reason for the inclusion of this aspect was to establish whether the developed materials had any significant bias against a particular group of learners in terms of gender and cognitive preferences.

5.3.1 Interactive influence of gender and treatment

The results of this study showed no significant interactive influence of gender and treatment on the attainment of all the assessed learning outcomes, for either the experimental or the control group (table 4.9). The lack of significant gender differences in the achievement of learners exposed to traditional teaching approaches seems to contradict earlier findings, which showed gender discrepancies in science attainment (Arnott et al., 1997; Howie & Hughes, 1998; Osborne, et al., 2003). However, the results corroborate earlier findings (Wierstra, 1984; Yager & Wield, 1999) that context-based approaches tend to narrow the science achievement gap between girls and boys.

In developing the context-based materials for this study, an attempt was made to make the materials gender sensitive. For example, the situation discussed in unit 9.2.1 (appendix VI), which involves the birth of an albino in a family, is an issue that is equally relatable to both boys and girls. The use of materials that are applicable to boys and girls in the same way is likely to arouse their interest and encourage participation in discussions to the same degree, and consequently achieve similar results. Research evidence (Cohen, 1983; Murphy, 1991) seems to support the assumption that when deliberate efforts are made to make teaching materials relatable to boys and girls in the same way, especially in activity-centred teaching approaches, the performance of the girls may be the same as that of the boys. This study has provided some empirical support to this assertion.

5.3.2 Interactive influence of cognitive preferences and treatment

Previous studies (Okebukola & Jegede, 1989; Tamir, 1988) have shown that achievement in science could be influenced by learners' cognitive preferences. In this study, the results showed no significant effects of cognitive preferences on learners' attainment of the learning outcomes in the experimental and control groups (table 3.10). This could be an indication that the teaching materials were accessible to all learners, regardless of their cognitive preferences. Most importantly, however, the findings suggest that the developed materials had no adverse effect on learners with different cognitive preferences in the achievement of learning outcomes.

The results did not show any significant differences between the pre- and post-intervention cognitive preferences of learners, either. This is not surprising, since cognitive preferences are fairly stable over time (MacKay, 1975). A seven-week intervention was therefore unlikely to significantly alter learners' cognitive preferences.

5.3.3 Interactive influence of gender and cognitive preferences, and treatment

An assessment of the combined influences of gender and cognitive preferences on the attainment of the learning outcomes showed no significant interactive effect with the teaching approaches used. The explanations given earlier for gender sensitivity

and accessibility of the materials by learners with varying cognitive preferences (sections 5.3.1 and 5.3.2) could also account for this lack of influence in this instance.

To sum up, it appears that gender and learners' cognitive preferences did not independently or collectively significantly influence the attainment of the learning outcomes assessed in the study for either the experimental or the control group. The materials and approach used in this study could therefore be considered to have no significant bias towards particular groups of learners in relation to gender and cognitive preferences.

5.4 EVALUATION OF THE CONTEXT-BASED APPROACH DEVELOPED IN THE STUDY

The driving force for developing the materials and approach used in this study was the need to enhance learner performance in life sciences, specifically in genetics. From the findings of the study, it is clear that the context-based materials and approach were more effective than traditional teaching approaches in enhancing learners' achievement in genetics, problem solving and decision making.

The main features of the developed materials and the approach that could account for their efficacy in improving learner achievement appear to be the use of contexts that are familiar and relatable to learners in developing the teaching materials, and the use of a five-phase learning cycle to expose the materials to learners. A detailed evaluation of these features is provided below.

A review of the literature (Pilot & Bulte, 2006; Taasoobshirazi & Carr, 2008) suggests that the apparent inefficiency of existing context-based approaches in improving achievement could stem from shortcomings in design and developmental processes, and from difficulties in implementing context-based materials. Researchers (De Jong, 2008; Shiu-sing, 2005) have suggested that the contexts used to develop materials should not detract learners from the intended concepts, should not be so complicated and abstract that they confuse learners, and should not be irrelevant to the extent that they fail to motivate learners. Other researchers (Pilot & Bulte, 2006)

have pointed out that the relevance of contexts, in contextualized teaching, is influenced by time and regional priorities.

Previously, the contexts used to develop teaching materials were usually determined solely by adults without involving the learners (Bennett & Holmann, 2002). Teaching materials developed and used in this manner might not be suitable, relatable, facilitative or even appreciated by certain populations of learners. In addition, in both existing contextualized and traditional teaching approaches, materials developed by curriculum developers and educators for specific learners in different regions at various times are usually recycled over and over for different audiences. Hence the effectiveness of such materials in improving learner performance could have been compromised by changing priorities and preferences by learners.

Teaching and learning theorists (Dewey, Herbart, Piaget, von Glaserfeld and Vygotsky) as pointed out severally, recommend the use of materials that are familiar relatable and appreciated by learners, for effective learning. The development of the materials used in this study was based on contexts determined by the learners themselves. The materials therefore had the potential to meet the needs, perceptions, aspirations, time and regional priorities of the learners, as suggested in literature (De Jong, 2008; Pilot & Bulte, 2006; Shiu-sing, 2005). Learners exposed to the materials were likely to relate to, appreciate and engage more with them better than those determined by adults only.

Further, evidence from the literature (Gilbert, 2006: 960-966), as stated in section 2.2.2, suggests that the principles that guide the development of context-based materials include the following:

- 1 Context-based materials should provide a setting (social setting) in which learners may engage in mental encounters with events on which attention is focused.
- 2 The environment in which the mental encounters take place must be of genuine inquiry, which reflects the conditions under which scientists operate.

- 3 The way of talking within the environment should be developed by the learners.
- 4 Preconceptions of learners must be used, and their explanatory adequacy explored.

Some of the context-based models and materials that are used to teach science do not take all of these principles into account. For example, models based on 'contexts as the direct applications of concepts' do not usually provide social settings, they evoke little background knowledge, do not provide high quality learning tasks, and they do not provide opportunities for learners to develop a specific scientific language' (Gilbert, 2006: 967). Omission of some of the suggested principles for developing context-based materials could impede the effectiveness of the materials in enhancing learner achievement.

The five-phase learning cycle that was used to implement the context-based materials provided learners with opportunities to explore real-life societal, environmental and personal issues and to relate them to concepts and ideas taught in science classes, which are essential for effective learning as suggested by educational theorists, such as Dewey, Herbart, Piaget, von Glaserfeld (Abraham & Renner, 1986; Bybee, et al., 2006; von Glasersfeld, 1989). By basing lessons on authentic societal and environmental sceneries, the developed materials provided social settings within which to engage learners in cerebral activity during the study of genetics concepts, as required in contextualized teaching (Gilbert, 2006).

Further, the learning activities in the developed materials were mostly inquiry based, requiring learners to raise and explore questions about familiar situations, use relevant information to seek solutions, and to make decisions on socio-scientific issues. This manner of learning is consistent with Dewey's model of reflective experience, which is required for effective learning. Furthermore, the learning activities were mainly learner-centred, involving discussions, debates and brainstorming sessions directed by the learners themselves, based on their preconceptions and comprehension of the issues, hence developing a specific scientific language, as suggested by Gilbert (2006). The learning activities were also significant in eliciting learners' prior knowledge, which according to researchers (Eisenkraft, 2003) is a critical part of effective learning.

The approach used in this study therefore embraced all the principles for developing effective context-based materials (Gilbert, 2006), which could have significantly enhanced its efficacy in improving learner achievement. In addition, eliciting learners' prior knowledge enabled educators to identify learners' alternative conceptions in order to take appropriate remedial measures during the content introduction phase. Moreover, learners were given an opportunity to reflect on the perceptions they had held before acquiring new scientific knowledge, hence they were able to rectify some of their alternative conceptions. Learner self-reflection, according to researchers (Abraham & Renner, 1986; Bybee, et al., 2006; von Glasersfeld, 1989) is a crucial element in learning. Finally, learners were required to apply learned scientific concepts to novel situations outside the classroom, as recommended in Herbart's model for effective instruction. As a result, learners were able to see the transferability of scientific concepts to varying contexts. These activities are likely not only to have enhanced learners' conceptual understanding, but also to have developed higher order thinking skills.

A notable challenge with context-based teaching has been educators' reluctance or inability to implement the approaches effectively. In most cases, educators are loath to learn and adopt new instructional approaches such as context-based teaching (Eilks, Parchmann, Gräsel, & Ralle, 2004). It is not unusual for educators to want to adhere to instructional approaches with which they are familiar, and which they perceive to have been successful. One of the contributing factors to educators' unwillingness to adopt new teaching approaches could be the use of national examinations with assessment requirements that, in most countries, differ from those of context-based approaches (Pilot & Bulte, 2006). Educators are often under strong pressure from learners, parents and examining boards to maintain conventional teaching approaches and familiar subject matter, which they regard as enhancing learner success in these examinations.

Lack of competence and cooperation from educators, in implementing context-based approaches, could limit the effectiveness of these approaches in increasing achievement in science. Pilot and Bulte (2006) contend that the attitudes of educators are a key factor in the success or failure of most educational innovations,

such as contextualized teaching. This is because educators are the ones charged with the responsibility of implementing the new educational innovations.

To ensure that the materials developed in this study were implemented effectively, the educators who taught them were thoroughly trained in context-based teaching competencies such as; context-handling, regulation of learning, and placing sufficient emphasis on the development of scientific knowledge and higher-order thinking skills (Stolk, et al., 2009; Gilbert, 2006). Further, the implementation process was closely monitored and supervised by the researcher to ensure that the principles of the approach were adhered to. It is possible that educators' competence and diligence in implementing the approach effectively could have contributed to the enhanced efficacy of the approach in improving learner achievement.

The described features of the developed materials and approach used in this study have not been explicitly exploited in a systematic manner in either the traditional or existing context-based approaches to the teaching of science. The explained features could therefore account for the significantly enhanced performance of the experimental group in this study.

Although the educators who taught the experimental group expressed positive views about the context-based materials and approach, and recommended them for teaching life sciences in schools, they indicated that its wider use might be hindered by time constraints and the heavy cerebral demand on educators.

Some educators who taught the experimental group pointed out that implementing the new approach in schools might have time constraints because in South African schools the duration for a lesson is about 40 minutes, whereas the time required to complete all five phases of the new teaching approach could be take longer. One of the educators, however, admitted that this possible time constraint could be insignificant if the teaching method is well planned and correctly applied. Moreover, the ultimate educational benefits to learners, of enhanced conceptual understanding and the development of higher order thinking skills are likely to offset the time spent in planning and applying the method.

Educators who implemented the approach also posited that it might present challenges to educators who have not been trained in this approach because it requires clear understanding of the concepts to be taught and careful planning by the educator. According to these educators, careful prior planning is necessary so that educators can raise appropriate questions to stimulate interest, respond adequately to questions raised by learners, be alert to learners' preconceptions and address them at an opportune time, as well as provide appropriate content for the situations being studied. These activities require substantial intellectual commitment by educators.

While the intellectual demand on educators may be a reality when using the approach, careful lesson planning and understanding of concepts have always been a requirement for effective teaching, and therefore should not be viewed as a new or negative attribute in this approach. Moreover, adequate training of educators would equip them with the necessary skills and practice to implement the approach effectively. In fact, one of the interviewed educators pointed out that the approach could be beneficial to educators because it forces them to ensure that they understand what they teach, so that they could be in a position to answer the questions which their learners may ask them.

Lastly, an educator from the experimental group inferred that the use of the approach in large classes might be difficult owing to lack of resources for practical activity. Nonetheless, the materials used in the approach can be devised cheaply from household items, such as beads, thin wires from cables, cotton wool and paper. In other words, effective use of the approach in large under-resourced classes could be easily accomplished through improvisation. Moreover, the context-based approach required learners to work in small groups, which lessens the difficulty of managing large classes, and the need for large amounts of teaching resources.

5.5 CHAPTER SUMMARY

In conclusion, the discussions in this chapter showed that the use of contexts determined by learners to develop the materials, and the five-phase learning cycle

were identified as possible determinants of the efficacy of the approach in improving learner performance.

Contexts decided by learners themselves made the teaching materials more familiar, relatable and interesting to them. The features of the learning cycle that were construed to account for enhanced learner performance include the interrogation of contexts by learners before scientific concepts are introduced; the introduction of relevant content in small manageable quantities; revisiting concepts and ideas again and again in various themes; linking content and contexts; learner self-reflections and applying learned content to new situations.

Both learners and educators from the experimental group appreciated the context-based approach that was used to teach genetics. Nonetheless, some educators indicated that use of the approach in schools might be hampered by time constraints, heavy intellectual demands on educators, and lack of resources (especially in large classes). These concerns could be addressed through careful planning and training of educators, as well as improvisation of materials for practical activity.

Comments from participants indicated that the traditional ways of teaching genetics were characterised by educator-centred teaching, lack of practical activity, and teaching of abstract concepts that could not be comprehended by learners. Consequently, both learners and educators from the control group were apprehensive about the performance of learners in genetics. Learners from the control group were discontented with the approaches used to teach genetics and blamed their educators for the difficulty experienced in the study of genetics. Their educators on the other hand were of the opinion that learners' reluctance to participate during lessons and to study genetics, and the abstract nature of genetics could account for poor learners' performance in genetics.