The Role of Computer Games and Social Constructivism in Skills Development of Learners from Different Educational Backgrounds

by

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DECLARATION

The experimental work described in this thesis was carried out at the Centre for Information Technology in Higher Education, University of KwaZulu-Natal, Durban, from February 2001 to August 2005, under the supervision of Prof. A. Amory.

I hereby declare that this study represents original work by the author and has not been submitted to another university. Where use has been made of the work of others, it is duly acknowledged.

We hereby certify that the above statement is correct.

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ABSTRACT

This study is positioned within a specific South African context where many learners not only lack access to resources but are considered underprepared and therefore are seen as academically disadvantaged. Research findings presented here centre on learning theories within the social constructivist paradigm, make use of a developmental research methodology and use a number of different research instruments.

The main objective of this study was to investigate the use of virtual learning environments, constructed as educational adventure games, as viable learning tools and to determine the influence of game play on skill development and overcoming learning difficulties. More specifically two educational games, *Zadarh* and *γKhozi* developed at the University of KwaZulu-Natal, were used to investigate the use of technology in classrooms that included underprepared and academically disadvantaged learners. *Zadarh* was designed to challenge learner misconceptions related to photosynthesis and photorespiration and was used to investigate and evaluate the effectiveness of games to overcome these misconceptions. *γKhozi* was used to introduce learners to issues related to HIV/Aids and to evaluate the use of such tools to develop skills. However,

It was first necessary to develop an instrument, based on the Persona Outlining Model (POM), to evaluate and measure skills. The POM uses a number of interfaces (literacy, communication and visualization skills) and properties (age, gender and socio-economic background) to describe a typical learner, or game player. The instrument based on these interfaces and properties was used to evaluate the skills of young South Africans from Buhlebemfundo, Qhakaza and Tholokuhle schools and two universities, namely, University of Zululand [UniZulu] and University of KwaZulu-Natal [UKZN]), all from the region of KwaZulu Natal, South Africa.

The majority of the sampled learners appear to lack appropriate visualisation, logical, mathematical, reading and writing skills and results suggest that poor performance may be associated with a low household income and poor English language skills. While participants (Buhlebemfundo, Qhakaza and Tholokuhle schools, and UniZulu and UKZN university students) who played *Zadarh* individually solved game problems, they still held many of the misconceptions. Further investigation revealed that when participants were unable to solve a problem they learnt by rote the solution to the problem. Playing *Zadarh* in groups and allowing participants to ask for clarification of assessment instrument questions showed that many participants developed a deeper understanding on the relationships between photosynthesis and respiration. Participants from Qhakaza were asked to play *γKhozi* in flexible groups which

changed from session to session. Using the previously developed skills assessment instrument showed improve visual, literacy and communication skills. Results strongly suggest that only through dialogue can misconceptions be overcome and that learning is a social activity as proposed by Vygotsky over 80 years ago. More specifically research presented here supports Vygotsky's Zone of Proximal Development, the role of play in development and the need for written language skills. The new art form of digital games when conceived as microworlds can play an important role in education if games support co-operation between players, peers and mentors, allow for exploration through play and support the development of reading and writing skills.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
BACKGROUND TO EDUCATIONALLY UNDERPREPARED AND DISADVANTAGED LEARNERS

1.0. INTRODUCTION

The digitalisation and convergence of computer and telephony technologies, which are the linchpin of the information and communication technologies (ICTs), have greatly influenced educational practices. It is not clearly known, however, if the ICT promise could enhance the education of the majority of students who come from disadvantaged schools and/or poor communities. This thesis attempts to explore the use of play and computer games that are part of the ICT as a tool to enhance teaching and learning.

Chapter 1 provides a background to the notion of academic development, with particular reference to underprepared and educationally disadvantaged learners. It is important to position the study within a specific South African context where it could be argued that it is only through access to quality education that many people can overcome poverty.

Chapter 2 chapter highlights the theoretical framework underpinning the study. This chapter discusses theories of learning (such as instructivism, constructivism, and social constructivism) which guided the study. The importance of theory in the development of ICT led education is also discussed.

Chapter 3 consists of a review of the literature related to the role of ICTs in learning and includes the part performed by cyberspace and virtual learning environments as media for educational curricula.

Chapter 4 critically examines the role of play and games, especially computer games, in education and their incorporation into the curricula.

Chapter 5 investigates the different methodologies employed in the study and the reasons for selecting specific research instruments and the tools and methods for gathering and analysing data.

Chapter 6 discusses “The Persona Outlining Model”, a model used to define a typical South African learner. This model provides many interfaces such as play, exploration, challenges and engagement but the discussion will be directed mostly towards the problem space that includes

the interfaces related to literacy, communication and visualization skills and properties such as gender and socio-economic background. This chapter also interrogates data attained from the results of literacy and communication skills based on Persona Outlining Model to ascertain if the skills levels of participants had improved.

Chapter 7 is divided into two parts with the first part investigating the use of a computer game (*Zadarh*) to overcome misconceptions held by students relating to their understanding of the relationship between photosynthesis and respiration. Secondly, it explores the use of a newly developed interactive learning game, *yKhozi*, to test the concepts explored in chapters 6 and 7 particularly those pertaining to the development of literacy and communication skills in social constructivist settings.

Lastly, chapter 8 gives some concluding remarks to the study and provides some recommendations for future endeavours.

1.1. BACKGROUND TO THE SOUTH AFRICAN EDUCATION SYSTEM

South Africa has a history of an education system designed to create and perpetuate inequality. Previously, the quality of education received depended mostly, if not entirely, on the colour and race of students and in some instances on the wealth of their parents. According to Naicker (2000) apartheid education emphasised separateness as it promoted race, class, gender and ethnic divisions rather than common citizenship and nationhood. There were different departments of education for the main race groups with resources allocated differentially to each (Dison and Murray, 1998). According to these authors, in 1953 Bantu Education Act was passed with the aim of producing labour for the South African economy. Apartheid education for blacks had successfully suppressed teachers' and pupils' intellectual and analytical abilities (Walker, 1990). Educational institutions, during the apartheid era, produced students with different academic standards and competencies because universities were prohibited from admitting black students and separate universities were created for different racial groups. Consequently, in April 1994, South Africa's first democratically-elected government inherited all the problems bequeathed by the divisive, unequal and fragmented education system that for the past half century had failed to adequately educate the majority of the country's people (Dean, 2000). Dean stresses that there was a high dropout rate among black school children linked to widespread poverty and social alienation, coupled with a lack of provision for millions children.

The Bill of Rights contained in the new South African Constitution of 1966 states that everyone has the right to a basic education, including adult basic education and further education, which the State, through reasonable measures, must make progressively available and accessible. The constitution in its endeavour to build a unified society had to undergo changes which prohibit discrimination of all sorts that includes, race, gender, social class and disability (The Constitution of South Africa, 1996). Thus, the constitution tries to redress the imbalances within the schools and to provide new curricula that develop a new sense of identity based on dignity and respect for all people, rather than on racial, gender and class division (Heinemann South Africa, undated). In 1997, the South African government launched a new curriculum called Curriculum 2005 (C2005). The intention was to introduce C2005 to all grades by 2005. According to the Department of the Government Communication and Information System (GCIS) (2005) C2005 is the brand name of the National Curriculum Framework introduced into schools in 1998 and based on the concept of Outcome Based Education (OBE).

> "OBE regards learning as an interactive process between and among educators and learners. The focus is on what learners should know and be able to do (knowledge, skills, attitudes and values). It places strong emphasis on co-operative learning, especially group work involving common tasks. The goal is to produce active and lifelong learners with a thirst for knowledge and a love of learning" (GCIS, 2005)

Heinemann South Africa (undated) lists a number of objectives this curriculum intends to achieve and these are to: (i) to provide learners with the linguistic skills and the aesthetic and cultural awareness so that they can function effectively and sensitively in a multicultural and multilingual society. (ii) To develop critical minds, able to use a variety of ways to gather, analyse, organise and evaluate effectively numerical and non-numerical information, and then communicate it effectively to a variety of audiences. (iii) To develop learners who can function in a multicultural and multilingual society aware of the human diversity of their society, and (iv) to develop learners who are able to use a variety of effective problem-solving techniques that reflect different ways of thinking in the ICT led global community. The learning areas include languages, mathematics, natural sciences, technology, social sciences, arts and culture, life orientation, economic and management sciences.

Although the country's constitution has put all these objectives in the forefront of the educational system, unfortunately according to the report of the Human Science Research Council (HSRC) of South Africa (Howie, 2004) the academic standard is still not improving. The study focused only on Grade 8 learners. The report describes the finding of Third International Mathematics and Science Study Repeat (TIMSS-R) of 1999 that shows that out of 26 countries which took part in the study, South Africa performed the worst in both subjects.

The report shows the results of the study done between 1998 and 1999 documented in the HSRC website. The first study South Africa participated in was carried out in 1995 when its performance was the worst out of 41 countries. This trend continued as is evident from the study completed in 1999 where on a scale of 800 points overall, South Africa with overall mean score of 275 a mark well below the international mean of 487.

In mathematics, South Africa had a 3-point decrease in the overall score between 1995 and 1999 which was not statistically significant (Howie, 2004). In other words, there is no real difference in performance between the pupils in 1999 and those in 1995. South Africa had a mean score of 275 in mathematics compared to the international average which increased by 2 scale points from 519 in 1995 to 521 in 1999.

South African pupils also performed poorly in science with a mean score of 243, which was well below the international mean of 488 (Howie, 2004). The South African scores were below the mean scores of all other participating countries, including the two other participating African countries of Morocco (323) and Tunisia (430) as well as those of other developing or newly developed countries such as Malaysia (492), Indonesia (435), Chile (420) and the Philippines (345).

Therefore, apartheid education did not prepare students for post-apartheid times driven by ICTs. Again, from the results of TIMSS-R as presented by the HSRC, it is clear that even the post-apartheid South African education system does not adequately prepare learners for this demanding role. Consequently, there is a need for reorganisation of the educational systems in order to meet these demands. One of the most damaging legacies of the apartheid era stems from the obvious inequalities in South African education (Miller et al., 1998). The higher education sector is faced with skewed and deepened problems arising from the peculiar historical and political context (Hartman and Warren, 1994). South Africa is faced with a profound challenge of educating, training and integrating a large proportion of its population who were previously denied the opportunity to move into the emerging information society (South African ICT Sector Development Framework, SAITIS, 2000). It will be argued, therefore, that in post-apartheid South Africa, however, the quality of education still depends on the type of education provided by a school, particularly as majority of the students still cannot afford the expensive tertiary education. Students from poor financial backgrounds attend poorly financed schools and receive education that is not comparable to the one received by students from more affluent groups, mostly from the previously advantaged ‘white’ schools. As a result,

a huge number of South Africans are not coping with tertiary education because the new educational dispensation is skewed towards the previously advantaged schools.

> "Although, in the post-apartheid era, inequalities in education are being addressed, the aftermath of the oppression has brought with it numerous educational problems, particularly for those students from 'disadvantaged' backgrounds who may experience difficulties coping with the demands of the university education system" (Miller et al.,1998).

For many black children, education is characterised by appalling learning conditions, inadequately qualified teachers and a language of instruction other than their own mother tongue (Luckett, 1995). Luckett further states that the excessive high first-year failure rate at South African universities is a clear indication of a major dislocation within the educational system. The educational systems, at both school and tertiary levels, have been dominated by instructivist learning approaches which do not develop the culture of problem-solving, free enquiry or active learning, but are authoritarian and conservative (Dean, 2000). The result is lack of preparedness for most students evident in tertiary institutions where most students are not coping with their course work (Miller *et al.,* 1998). According to Dean (2000) the problems faced by most blacks in South African schools include: (i) inadequately qualified teachers; (ii) problems of classroom space whereby black children are in classes often as large as 100; (iii) disaffected and under-qualified black teachers; and (iv) chronic under-funding of black schools. Therefore, students go through an educational system which does not only leave them underprepared but also does not equip them with essential ICT skills for effective participation in their tertiary education and in the information society as a whole. Hence, a need for higher educational institutions to keep pace with the socio-political and economic changes by preparing for an uncertain future and providing a technology-rich environment where students can obtain the continuously changing knowledge and skills needed to shape that future (Edgar, 1999). For this future, South Africa has to be competitive in the global economy and there is an urgent need for an educational system that embraces these technologies. Luckett (1995) asserts:

> "Universities are increasingly coming under pressure from governments and employers to be more accountable to society – to align their goals and priorities with national goals, to deliver more graduates with fewer resources and to ensure the acquisition of the skills and competencies demanded by a global economy and an information society".

The aims of the new democratic government's education initiatives have been to redress the educational wrongs of the apartheid years within a democratic framework of justice, civic responsibility, equality of opportunity, tolerance and stability (Dean, 2000). Dean further states that indeed the government abolished the old racial divisions and put in place an integrated

education system. The ruling African National Congress asserted in its policy paper on Reconstruction and Development Programme (RDP) that education must address the development of knowledge and skills that can be used to produce high-quality goods and services in such a way as to enable us to develop our cultures, our society and our economy (African National Congress, 1994).

While the government is trying to develop the curriculum inclusive of all races and cultures, the problems emanating from the apartheid era continue. For example, the overall education expenditure is simply too low to deliver to the most disadvantaged schools (Tikly, 1997). Dean (2000) argues that schools in disadvantaged areas are still suffering from problems of acute resource shortage, overcrowded classrooms and demoralised and under-trained teachers. In contrast, the ex-white schools have an immeasurably superior capital resource base from the past to draw upon, and inherited racial and economic demographics enable these schools to charge high school fees to pay for additional resources. Dean (2000) says that the black township schools can charge only minimal school fees, which unfortunately their communities simply cannot afford. Wealthier blacks either move from the townships, or bus their children out to ex-white or ex-coloured schools. Therefore, good education is still dependent on colour and wealth. In effect, there has been accentuation of previous patterns of differing opportunities for the majority of black children still receiving education of lower quality than that of their White or affluent Black and Coloured counterparts.

Therefore, this research which is guided by the tenets of 'academic development', namely, disadvantaged and underpreparedness, which "describe a distinctive category of student" (Miller *et al.,*1998) – will investigate how problems could be addressed in such a way that students will be ready to participate in tertiary education. It is, therefore, the aim of the researcher to investigate these concepts which are a legacy of racial discriminatory policies which produced and keep on producing learners with differing literacy and communication skills. Again, educationally "disadvantaged" will be studied as a problem arising from instructivist methods of education which are argued by many educationalists to be ineffective. This type of learning does not assist learners to play a meaningful role in their own learning and importantly does not help them for tertiary school education.

1.2. EDUCATIONALLY "DISADVANTAGED" STUDENTS

Although in the democratic South Africa there is no individual who is educationally or politically oppressed the definition provided by Moll and Solinimsky (1989) is still as pertinent today due to the inequalities in land ownership and quality education. These authors argue that

in South Africa the term 'educationally disadvantaged' is 'taken for granted' and used to define 'educationally oppressed black students'. These writers argue that what constitutes being 'disadvantaged' is 'unclear' and, consequently, the term is used as a label, without a firm understanding of its causes and consequences. However, what many writers agree on is that the social inequalities have led to the poor people or "disadvantaged" groups receiving an education that is inferior to that of affluent members of societies. In newly emerging countries educational failure is part of a cycle of poverty, social ineffectiveness and ignorance, which is repetitive unless the links composing its component parts are broken (Birch and Gussow, 1966). As a result, the systematic relationship between social conditions and educational competence is neither something new nor even a newly discovered phenomenon. Therefore, for the disadvantaged poor people to break away from their misery they demand not merely education to a minimum level of employability, but education that will prepare them to participate at all levels of an increasingly technical society.

This notion of disadvantaged learners, therefore, refers to socially and/or economically less affluent members of society. Hence, in this research the term disadvantaged refers to mainly learners from less affluent communities who are products of an education that leaves them underprepared to participate effectively in tertiary education. The disadvantaged will also refer to learners who are a product of a particular type of educational system which does not develop analytical and other cognitive skills. The key goal of education should be:

> "to enable students to develop the cognitive and conceptual skills, both general academic and discipline-related, required to interpret, evaluate and construct 'artifacts' of knowledge through the appropriate use of discourse, theory and evidence, as well as the enthusiasm, motivation and metacognitive abilities to become independent and adaptable learners who can function in our modern 'information society'" (Hartman and Warren, 1994).

The disadvantaged learners aare a product of an educational system that does not equip learners with appropriate skills. This therefore, contributes to the notion of being educationally disadvantaged and as a consequence learners are underprepared to participate in tertiary institutions and even in the wider community.

1.3. EDUCATIONALLY "UNDERPREPARED" STUDENTS

Underpreparedness cannot be separated from poor social and economic backgrounds of students, and consequently , is part to the concept of 'educationally disadvantaged'. It is argued that the need for more access to higher institutions of learning by students, particularly those from poor economic backgrounds, has led to a call for these institutions together with

governments to provide financial aid to needy students as "experience has shown that access cannot be separated from financial aid" (Hartman and Warren, 1994). "Underprepared students come from all economic situations and geographic areas even though they are disproportionately poor" (Roueche and Roueche, 1999). Roueche and Roueche (1993) explain that for learners to overcome their status of underpreparedness may take a long time as illustrated by the US where learners are still leaving high school underprepared just like in the mid-1960s and with competencies currently at the lowest levels in American history. Underpreparedness is, therefore, a major problem in academia as it hinders students' progress. Gagne (1985) postulates that the ability to learn new material depends on the mastery of prerequisite capabilities at a prior stage of learning.

Underpreparedness is described as an under-development, or the failure of students to develop academically (Miller *et al*., 1998). They argue that in South Africa the obvious common denominator of the majority of underprepared students is that they are second language students studying in English (or Afrikaans), a language that is not their mother tongue. Underpreparedness is often blamed on language, culture and economics. A significant problem for underprepared students is that their (predominant) 'African' culture does not facilitate the interpretation and understanding of texts rooted in a predominantly 'Western' culture (Machet, 1991). In the process of analysing a text, it is inevitable that the reader will impose their own past experiences and background knowledge onto the reading material (Miller et al., 1998). Hartman and Warren (1994) argue that certain premises need considering when shaping curriculum structures because of differing levels of preparedness. For example, firstly, there will be a continuation of the demands for increased access to university by historically disadvantaged students; secondly, the level of preparedness of these students is unlikely to change significantly in the next five to ten years (Fisher and Scott, 1993); thirdly, it is unlikely that universities will be pressured into offering greater access to mature, part-time students as part of reconstruction and development, who will introduce different dimensions to the concept of academic preparedness (Taylor, 1993); and fourthly, improving the level of academic preparedness for undergraduate study can most effectively be achieved within the university environment and preferably within the disciplines (McGrath and Spear, 1991).

It is important to note that, notwithstanding the level of underpreparedness and all the surrounding problems, most South African students who enter university with low academic preparedness because of under-resourced secondary schooling, just like their European and American counterparts, are still deeply concerned about their degree marketability (Hartman

and Warren, 1994). The government tried to intervene by introducing a curriculum Outcomes-Based Education.

1.4. GOVERNMENT INTERVENTION AND OUTCOMES-BASED EDUCATION

The demise of apartheid fast-tracked by the emergence of a new democratic society led to new thinking about education. The new government was aware that if the country was to compete on the global stage, the global imperatives required a post-modern education system which demanded a student–centred approach, different from the apartheid education characterised by rote learning, loyalty, obedience, narrow cultural advancement, and a deliberate inculcation of misinformation and ethnic prejudices (Asmal and James 2001). Thus, the South African government opted to replace the previous education policy with a constructivist, Outcomes Based Education (OBE) (Skuy *et al*., 2001) in its primary and secondary school curricula (Halloun, 1998) instead of a content-driven curriculum (Asmal and James 2001). The 1996 White Paper on Education and Training (Department of Education, 1995) saw the goal of education as to uplift individuals, including those from previously disadvantaged communities, so that they could contribute to their own development and that of their society (Waghid and Fakier, 2004). This new paradigm was therefore, intended to promote equity, equality, and social and cultural empowerment.

Outcomes-Based Education has its roots in the educational reforms of the 1960s namely, mastery learning and competency-based education (Soudien *et al*., 1997). According to these writers, the mastery learning movement was initiated by Benjamin Bloom, an American cognitive psychologist who worked on the premise that all learners are able to master desired outcomes if educators refashion the time and instructional parameters in which learning takes place. They further stated that the competency-based education movement was a reaction to the changing job market in the United States in the late 1960s with questions arising about the role of education in preparing young people adequately for their future life roles. The basic premise of competency-based education is the integration of outcome goals, instructional experiences, and assessment devices. OBE infused certain themes from these movements in an attempt to shift existing educational practices to include objectives tied to "learner outcomes, core and extended curriculum development, mastery learning, accountability via an information management system, and criterion referenced assessment" (Capper and Jamison, 1993). These scholars, however, assert that in practice, this approach remains largely rhetorical, partly because little agreement has been reached over what competency actually represents.

Outcomes-Based Education has a number of underlying principles and Spady (1994) proposed four: (i) Clarity of focus: where education systems should be organised in such a manner that teachers and students can clearly focus on what learners need to achieve. (ii) Designing back: this one is related to the first principle, and means that in designing curriculum what students need to finally achieve must be clearly defined. (iii) High expectations: where teachers must establish challenging standards high enough to keep all students engaged and encouraged during their learning. (iv) Expanded learning opportunities: students do not all learn in the same way or at the same time. Therefore, "The most important principles of outcomes-based education are that planning, teaching and assessment should focus on helping learners to achieve significant outcomes to high standards" (Killen and Hattingh, 2004). Dalziell and Gourvenec (2003) contend,

> "OBE advocates a holistic, constructivist approach to learning, encompassing educational theory and structural issues in education as well as classroom practice and … it most significantly encourages educators and students alike to centre their efforts on demonstrating the achievement of pre-determined outcomes.

The constructivism aspect of OBE stems from its insistence to bring on board the experiences of both the teacher and the learners. Central to OBE is teacher preparation approaches and methodologies to teaching, learning and assessment, as well as demonstrated learner competence (Ndhlovu, 2002). Ndhlovu further stresses that OBE marks a shift from a limited focus on the inputs of teaching and learning to the processes and outcomes. Skuy *et al*. (2001) insisted that *Outcomes* in OBE refer to knowledge, skills, values and/or attitudes that an individual is expected to demonstrate in a given learning situation and at the end of each learning process. OBE focuses on the processes necessary for learners to achieve these outcomes. Skuy and friends argue further by stating that OBE is based on the belief that all children, irrespective of their background, can successfully learn. Learners are actively involved in their own learning, and flexibility of teaching style and content is stressed. This is in contrast to other teaching and learning paradigms most notably content-based models which give precedence to content over outcomes (Dalziell and Gourvenec, 2003).

1.4.3. The South African Government Stance

Coming out of an era where education was mismanaged and misused, interest groups, such as teacher unions and institutions of higher education, were sceptical about OBE when the South African government introduced C2005 in year 2000. At least two types of criticisms (a) of pedagogical nature, and (b) relating to infrastructure and expertise were levelled against this new paradigm as explained below.

1.4.3.1. Pedagogical Problems

In the South African context, Fakier and Waghid (2004) raise three main pedagogical problems regarding OBE:

(i) *Economic growth and technological development vs. Critical thinking*: They assert that there is an implicit tension between technological education and education for democratic awareness and critical thinking. They argue that it may be politically correct to go with the former at the expense of critical awareness and critical thinking given the huge ethnic inequalities in skills and competences in the nation's labour force. Fakier and Waghid further contend that the government has bought into the agenda of the neo-liberal, free market economy, marked by fiscal restraint which does little to promote critical thinking;

(ii) *Transparent and observable terms:* OBE fails to recognise that human behaviour and understanding entail a complex series of activities, none of which can be defined in terms of outcomes. Therefore, OBE is flawed because of its insistence to interpret the complexity of human activity in terms of outcomes although human action and understanding cannot always be explained as such; and

(iii) *Authoritative outcomes:* Those who formulate policy are also guilty of constructing outcomes that imply that their noble claim to operate in a framework of critical thinking becomes flawed by power structures such as those of control and manipulation (Waghid, 2000).

1.4.3.2. Expertise and Infrastructural Problems

Skuy *et al.* (2001) raise two problems regarding expertise and infrastructure and these are that: (i) At the time of implementing OBE teachers were ill-prepared to undertake their new roles because of the minimal training they had received; and (ii) The felt need to rationalise resources, to retrench teachers, and to redeploy others to more disadvantaged areas led to a great deal of acrimony, tension and resentment.

1.5. INITIATIVES BY UKZN FOR ADDRESSING EDUCATIONAL PROBLEMS

The government is not the only institution concerned with these problems of academic development but academic institutions are also doing their part by starting initiatives addressing such issues. This research is one such endeavour that uses learning games to address academic problems. In addressing these two problems of academic development, of underpreparedness and that of academically disadvantaged, two games – *Zadarh* and *yKhozi* – developed by the University of KwaZulu Natal are going to be used to investigate the suitability of play in

improving the academic preparedness of learners. In this regard, the effectiveness of two games (i) *Zadarh* – which addresses questions of photosynthesis and respiration, and (ii) *yKhozi* which addresses literacy and communication topics will be examined. However, before one could do so, the typical South African learner will be determined with the usage of the Persona Outlining Model (POM) developed by Amory and Seagram (2003).

1.5.1. *Zadarh*

Zadarh is an adventure game designed to provide learning resources to address specific misconceptions related to photosynthesis and respiration, evolution, mendelian genetics and 2D/3D visualization. This game covers a number of portals, each associated with a single biological concept.

> At the start of the game the player is informed that a scientist developing new viruses has been killed by one of his creations. The research laboratory has been evacuated and sealed to prevent the spread of the virus. The player, wearing a biohazard suit, is then invited to undertake a mission to find an anti-viral component that the scientist has hidden in the research laboratory. Successful completion of the next level, based on photosynthesis and respiration, provides the player with a supply of oxygen, a carbon dioxide cylinder used to extinguish a fire, and vials containing DNA bases. Basic understanding of Mendelian genetics is used in the next level where the player finds seeds that have been molecularly altered to contain the anti-viral DNA sequence that is used in the final level to develop a vaccine. The mouse was used for all navigation through, and interaction with the game. In each scene a player is able to walk forward or backwards, or is able to turn right or left. While investigating the game space the player finds objects, which can be collected, and solves puzzles to gain additional information or to progress to other game areas (Amory, 2001).

The photosynthetic and respiration level of *Zadarh* is used in this study to evaluate the use, and educational benefit, of complex and richly layered multimedia with learners from different education settings (urban and semi-urban environments).

1.5.2. *yKhozi*

yKhozi is a constructivist 3D virtual world adventure game that includes a number of knowledge domains "each centred around an aspect of South African heritage or culture," Seagram (2004), designed as microworlds. A single, microworld, or portal, related to important African diseases (HIV?IAIS, Tuberculosis, malaria and cancer), is used in this study to better understand the use of such tools within an African context.

1.6. STUDY GOALS

The primary objective of this study, therefore, was to determine the educational value of games where a sample of participating learners came from a wide range of backgrounds. In order to

realise this objective it was necessary to first design a research instrument to describe learners in terms of both quantitative and qualitative data as proposed by the POM and thereafter to use this model to evaluate the effect of games play on skills.

A secondary objective was to assess the applicability of the use of educational games with learners from a variety of backgrounds (university and senior school students from urban and semi-urban environments). Two educational games of *Zadarh* and *yKhozi*, which covered different topics are played by learners to ascertain if they can be used to adequately address learners misconceptions while enhancing their problem solving skills such as literacy, communication, memory and logic. Each part of the study also builds on the results obtained from previous parts of the research.

1.7. PARTICIPATING SCHOOLS

Three schools – Buhlebemfundo, Qhakaza, and Tholokuhle – and two universities (Zululand [UniZulu] and KwaZulu-Natal [UKZN] participated in this study. The three schools and UniZulu consisted mainly of isiZulu first language speakers and were located in the KwaZulu Natal semi-rural areas except Buhlebemfundo situated in the outskirts of Durban, while UKZN's population was more mixed and came from urban areas across the country. There were 55 participating students from Buhlebemfundo, 26 from Qhakaza, and 51 from Tholokuhle and were all matric students (Grade 12). There were also 27 students from UKZN (first year computer science) and 30 from UniZulu (first year Business Information Systems). The study was divided into three categories with each school participating in at least one of them while it is important also to note that Qhakaza learners participated in all three studies.

With the exception of UKZN, the participating institutions are based in the areas previously (apartheid area) considered as black. Despite current government interventions many of these areas are still poorly resourced. Both universities (UKZN and UniZulu) and a single school (Tholokuhle) have functional computer local area networks. However, Tholokuhle has only limited Internet access. In order to participate in this study participants from Buhlememfundo and Qhakaza made use of UKZN and UniZulu's resources.

1.8. CONCLUSION

The ICTs revolutionary impact on the way people do business, live and learn has opened opportunities for scholars and schools to use in enhancing learning. There is a great demand to incorporate these technologies into education and other social and economic spheres in order to improve lives, particularly of those disadvantaged ordinary citizens. In South Africa,

educational institutions are experiencing many changes, including, the need to restructure and meet the demands for greater equity, equal access, redress, and social and cultural empowerment while still delivering quality education to all. In addition, the economic demands are pressurising South African universities to develop curricula which address both national and global needs.

This chapter briefly outlines the research direction of this project in an attempt to find teaching and learning solutions for the disadvantaged members of the South African society who are generally underprepared and therefore unable to engage fully in tertiary education. The following chapter will discuss the dominant educational theories of learning as important pillars of education.

CHAPTER 2
DOMINANT EDUCATIONAL THEORIES

2.0. INTRODUCTION

The previous chapter introduced the concepts of academically disadvantaged and underpreparedness, within the South African context, and their contemporary origins and highlighted changes to the South African educational practices in order to set the stage for this study. This chapter will examine the place and role of theory in post-modern education and its contribution to the design and development of learning environments and evaluation models. This study was carried out within the broader context of constructivist learning philosophy and was concluded upon establishing that social constructivism was more effective in IT led learning and teaching, particularity where play and educational games are used. Constructivist and the social constructivist learning theories are, therefore, used to explain the acquisition of skills and knowledge in a post-modern classroom that may include Information and Communication Technology (ICT). The dichotomy between instructivism and constructivism is also discussed. The endeavours of the new democratic South African government to introducing an inclusive education based on theories of constructivism while discarding the old instructivism paradigm are also highlights.

2.1. EDUCATIONAL THEORIES OF LEARNING

Throughout history education has been dominated by reflections on the best ways learners could acquire knowledge, that is, the techniques and theories of learning, attitudes of society, and the social and economic context (Foreman, 1987). Also, the emergence of new technologies often precipitate educational debates that influence contemporary education and can impact on society and culture (Dumestre, 1999). Dumestre contends that the end of the agrarian and the beginning of the industrial age saw debates about what should be the content of the new education. The Progressives led by Dewey in the early part of the 20th century critiqued the earlier dominant traditionalist view of learner as a passive vessel to be filled with knowledge. Today, the emergence of ICT is influencing 21st century education practices just as the industrial age influenced education of the 20th century. Therefore, the question then and now according to Dumestre (1999) is still “what philosophy of education has the potential of addressing the needs of our time?” Good and Brophy (1990) argue that there are two main schools of thoughts for acquiring knowledge. In the first instance, a person may attempt to memorise the new information without relating it to anything already known and this is known as rote learning. The second position is where learners try to make a connection to something that they already know from experience. Therefore, knowledge acquisition involves either recall from memory or

assimilation into a pre-existing world view built through experience. Such types of knowledge acquisition support a variety of different educational theories of learning including instructivism (which often embrace behaviourism) and constructivism. In this section, the theories of instruction and construction are briefly discussed.

2.1.1. Traditional (Instructivism/Behavioural) Paradigm

The traditional or behavioural theories of learning draw largely from the work of Tyler (1949) who expressed curriculum as a product or a plan (Luckett, 1995). Other key players in the development of the behaviourist theory are Pavlov, Watson, Thorndike and Skinner (Mergel, 1998). Mergel stresses that some scholars can trace behaviourism, as a learning theory, back to Aristotle, whose essay "Memory" focused on associations being made between events such as lightning and thunder. The theory of behaviourism concentrates on the study of explicit behaviours that can be observed and measured (Good and Brophy, 1990). Mergel (1998) asserts that this theory views the mind as a 'black box' where response to stimulus can be observed quantitatively, with the involvement of little thought process. In other words, the curriculum is conceived of as a set of objectives and teaching 'inputs' which are subjected to a process of teaching and learning designed to attain certain 'outputs'. It is assumed that these outputs can then be measured against the original objectives. Luckett (1995) describes the main features of this traditional paradigm as predetermined 'supply-led' curriculum that takes little cognisance of learners needs, where knowledge is treated as an object broken down into separate and disconnected blocks for consumption without debate or interrogation, progress is measured using most recall tests and an educational ideology that entrenches, preserves and reproduces established power relations.

2.1.2. Criticisms of Instructivism Paradigm

Freire (1973), a critic of instructivism and a proponent of the critical consciousness theory, asserts that within the instructivism theory teachers think of reality as something motionless, static, compartmentalised and predictable. Freire used a metaphor of banking whereby, education becomes an act of depositing, students are the depositories and the teacher is the depositor. The more students work at storing the deposits entrusted to them, the less they develop the critical consciousness and this could hinder their contribution to the world as banking education is either misguided or mistrustful transformers of that world. Thus, the role of a teacher is to 'fill' students with contents of their narration, detached and disconnected from reality that produced them and which give them significance (Freire, 1973). In discarding the traditional paradigm, Freire in concurring with other scholars such as Piaget argues that there is

a need for a liberating education, which adopts the concept of people as conscious beings. This means that there is a need for education that promotes critical thinking. This, therefore, leads to the second major paradigm, constructivist theory.

A number of other criticisms could be levelled against instructivist (behaviourist) approaches to learning, and include an idea that there is only one objective interpretation world view (positivist) (Margules, 1996), where information is equated to knowledge (Ramberg and Karlgren, 1998) and is neither interrogated or reflected upon. Also his approach focus on content itself rather than the learning process where information flows in one direction (from the expert to the passive absorber) (Finn *et al*. 1996; Diaz and Bontenbal, 2000).

This traditional/instructivism, paradigm was the dominant learning theory of the apartheid times where industrialisation was the dominant mode of production of the South African economy. The instructivism praxis allowed the apartheid regimes to enforce their will more easily on all spheres of education, particularly on the outcome of a schooling system. This paradigm allowed authoritarianism in the classroom and discouraged critical independent thinking. Learners had to regurgitate what the textbook and the teacher claimed to be the acceptable answers. The thinking of learners, who were from the different social, economic, racial and cultural background, did not matter in this curriculum. This introduction of democracy in South Africa allowed the new government to introduce a new outcome based curriculum based on theories of constructivism in 1998.

By introducing the Outcome-Based Education, the South Africa government tried to establish a more democratic learning paradigm based on constructivism theories which allowed critical thinking and the questioning of authority of the textbook and the word of the teacher (Department of Education, 1997). In an endeavour to democratise the classroom the government introduced OBE through what Ndhlovu (2002) stressed as a shift from a limited focus on the inputs of teaching and learning to the processes and outcomes. The elements of the theory of constructivism are explained in the following section.

2.1.3. Constructivism (Critical) Paradigm

In contrast to the traditional paradigm of direct instruction is the philosophy of constructivism. Constructivists in education are closely aligned with the theories of Piaget (Butts and Brown, 1989). According to Pountney *et al.* (2002) there is no single constructivist position in the field of education as it does not represent a distinct theoretical position. Doolittle and Camp (1999) suggested that constructivism is better understood as a continuum. The assumptions that

underlie this continuum vary in a number of respects and have consequently resulted in the development of a variety in the types of constructivism that are divided into three broad categories: Cognitive Constructivism, Social Constructivism, and Radical Constructivism.

Constructivism is closely aligned to other theories such as constructionism and critical paradigm. Constructionism is a theory that locates meaning in language and the implied socio-cultural context (Steffe and Gale, 1995). The critical paradigm is an extension of the hermeneutic/practical paradigm that adopts a social constructionist view of curriculum (Luckett (1995). Inherent in constructionism is the concept that it is through language, communication and social constructs that meaning is derived. At the same time there also exists constructivism that describes learning as occurring through interactions with one's environment and culture. At the heart of constructivism is the idea that learning involves individual constructions of knowledge and describes learning as occurring through interactions with one's environment or culture. The potential of learning at different levels grows as the environment becomes richer and more engaging for the learner (Rieber, 1992). Constructivism places emphasis on the mental processes involved in establishing meaning and requires self-regulation and the building of conceptual structures through reflection and abstraction (Dick, 1991).

The constructivism paradigm, therefore, is based on what Freire (1973) termed the critical thought which brings to the fore several stages of consciousness. The critical consciousness is a student-centred dialogue, which problematises generative themes from everyday life as well as topical issues from society and academic subject matter from specific disciplines (Shor, 1993). Shor further states that constructivism is participatory, democratic, interactive and co-operative, relevant, includes critical debates and research, requires dialogue and participation, support multiculturalism and fosters the broadest development of social equality and equity.

The introduction of OBE curriculum in South Africa is the affirmation of the importance of constructivism in education, particularly in multiculturalism and multilingualism environments. It allows of individual expression and accommodation of diversity supports a curriculum that is dialogic and respect the dignity of each learner.

Cronjé (1997) synthesises the characteristics of constructivist learning as where learning is constructed from the experience of the learner, interpretation is personal, learning is an active process whereby experience is converted into knowledge and skills, learning is collaborative, thus allowing for multiple perspectives, knowledge is situated in real-life (which is ideally where learning should take place) and testing should be integrated with the task.

2.1.4. Criticisms of Constructivism Paradigm

The constructivism theories have their critics who are often damning in their observations of what are philosophies much less open to the rigorous scientific testing inherent in a behaviourist paradigm (McMahon, 1997). Constructivism focuses on the individual interpretation of a perceived external reality and this leads to the criticism that constructivism is old unpalatable, "empiricist wine in a new bottle" (Matthews, 1992). Mathews argues that constructivists seldom extend the analysis to be inclusive of social and communitarian dimensions of cognition where according to Freire and Hegel, "it is the 'we think' that determines the 'I think' and not the other way around." Another argument raised by Mathews is that knowledge is already available and individuals just use it appropriately. "Which particular patterns of belief, or theories, in a society constitute knowledge is not a matter of individual construction; individuals may appropriate intellectual useful understandings, but such appropriation is dependent upon knowledge being available" (Mathews, 1992). Constructivist strategies according to Merrill (1997) are often not efficient and result in a trial-and-error approach to the learning.

The introduction of constructivism paradigm opened spaces for new experiences and voices, particularly those which were considered inconsequential and in the South African schooling system (Department of Education, 1995). Languages and voices of those previously disadvantaged played a major role in the new curriculum. These voices became crucial in the development and improvement of South African curriculum and in providing equity and equality. Learners and teachers from different backgrounds could now contribute meaningfully to learning and teaching, as knowledge is no longer the exclusive terrain of the few Whites and privileged Blacks but a space for all. This realisation led to the introduction by the new government of a more accommodating curriculum named Curriculum 2005.

2.1.5. Social Constructivism Paradigm

Social constructivism is closely associated with many contemporary theories, most notably the developmental theories of Vygotsky, Bruner and Bandura's social cognitive theory (Kim, 2001). "The social constructivist version of Vygotsky, who in an effort to challenge Piaget's ideas developed a fully cultural psychology stressing the primary role of communication and social life in meaning formation and cognition" (Boudourides, 2003). According to Bruffee (1983) Vygotsky's main relevance to constructivism derives from his theories about language, thought, and their mediation by society. Some of the proponents of social constructivism have taken the criticism levelled against constructivism into their repertoire and elevated knowledge creation from the individual to a group of individuals (Taylor *et al.,* 1997). In offering the distinction between constructivism and social constructivism Salomon and Perkins (1998) argue that these

are two conceptions of learning each with its own metaphor. On the one hand, there is the conception of the individual learner, emphasizing the acquisition of knowledge and cognitive skills as transferable commodities. On the other hand, there is the socio-cultural conception of learning as a collective, participatory process of active knowledge construction, emphasizing context, interaction, and situatedness. Social constructivism emphasizes the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (Derry, 1999; McMahon, 1997). Social constructivism shows that learning is not a purely internal process, nor is it a passive shaping of behaviours. Vygotsky favoured a concept of learning as a social construct which is mediated by language via social discourse (McMahon, 1997). The most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously completely independent lines of development, converge (Rogoff, 1990). A key aspect for this theory is that knowledge is socially constructed and thus contested.

Taylor *et al.* (1997) illustrate that social constructivism combines both the constructivism and critical theories of learning. They argue that from constructivist theory comes a view of learning as a process of constructing new knowledge within the mind by reflecting on the viability of one's existing knowledge in light of new experiences, and a socially-mediated process of negotiation of meaning amongst a community of learners. While from critical theory comes a view of an empowered learner as one who seeks to understand others' understandings through an interest in open communication, and reflects self-critically on the unconscious and shared beliefs and values that shape her routine social practices.

Criticism levelled against social constructivism is the type of learning it supports. Taylor *et al.* (1997) argue that while it may be true that social negotiation is a useful approach to achieving consensual understanding of ill-structured subject matter, even in the 'softest' subjects there is often a body of undisputed knowledge.

From the inception of Curriculum 2005 investigative approaches based on social constructivism theory were envisaged as the bases for the new curriculum (Kwanele, 2000). The new South African government embraced social constructivism because the theory accommodates the diversity of languages, cultures, etc. One of the pillars of social constructivism is language and through which people make meaning through negotiate) interact socially, politically, economically, culturally and spiritually. Social constructivism therefore supports multilingualism goals of the curriculum 2005 that affords learners the opportunity to develop

and value their home languages, cultures and illiteracies and other languages in order to develop a shared understanding of a common South African culture.

2.1.5.1. Assumptions of Social Constructivism Paradigm

Kim (2001) raises specific assumptions about social constructivism, which include reality, knowledge and learning. Social constructivists believe that reality is constructed through human activity where members of a society together invent the properties of the world (Kukla, 2000). Thus, reality cannot be discovered as it does not exist prior to its social invention. Constructivists also believe that knowledge is a human product that is socially and culturally constructed (Gredler, 1997). Individuals create meaning through their interactions with each other and with the environment they live in. Learning is, therefore, a social process. It does not take place only internally, nor is it a passive development of behaviours that are shaped by external forces (McMahon, 1997). Social constructivist perspectives on teaching and learning emphasise the cognitive and social activity of learners in co-constructing their knowledge (Taylor *et al.,* 1997). Meaningful learning occurs when individuals are engaged in social activities (Fennimore and Tinzmann, 1990).

2.1.5.2. General Perspectives of Social Constructivism on Learning

Social constructivists see as crucial both the context in which learning occurs and the social contexts that learners bring to their learning environment (Kim, 2001). Gredler (1997) raises and discusses four general perspectives that inform learning which are facilitated within the framework of social constructivism. These include the use of cognitive tools, and complex and relevant tasks that include important concepts from different disciplines (idea-based construction); knowledge, meaning and understanding from different perspectives that emerge during learning activities (emergent construction); and the explored relation between people and their environment (situated cognitive constructivist focus).

2.1.5.3. Social Constructivism and Instructional Models

Learning models based on the social constructivist perspective stress the need for collaboration among learners and with practitioners in the society (Lave and Wenger, 1991; McMahon, 1997). Lave and Wenger (1991) assert that a society's practical knowledge is situated in relations among practitioners, their practice, and the social organisation and political economy of communities of practice. For this reason, learning should involve such knowledge and practice (Lave and Wenger, 1991; Gredler, 1997). This has significant implications for the Web

as a medium of communication. While it may not be highly interactive in a physical sense, the Web has strong potential for social interactivity. The goal of this type of approach is the achievement of 'virtual communities' of learners on the Internet working in small collaborative groups to achieve a common goal (Dillenbourg and Schneider, 1995). The design and development of the two microworld games understudy, *Zadarh* and *yKhozi,* were informed by the theories of constructivism and social constructivism.

Traditional Internet communication tools such as e-mail, newsgroups, Internet Relay Chat, and Multiple User Domains offer both the rapid synchronous communication of normal speech as well as asynchronous interaction which may help to promote a more reflective metacongitive approach (McMahon, 1997). With the use of Web browser plug-ins and server software such as Ichat, such facilities are now becoming available in a more cohesive form on the Web. Examples of learning through communication can be seen in commercial environments such as TopClass (WBT Systems, 1997) which have no actual content but provide the functionality required for real-time communication and collaborative learning.

Within the social constructivist paradigm, the determination of levels of interaction between learners is important, particularly where learning is done through VLEs. Therefore, the subsequent section tries to interrogated the notions of social capital and social networks, and the position of each learner within the IT led learning community. John and MacArthur (2000) argue that high *social capital* is crucial for creating successful virtual learning environment.

2.1.6. Social Capital and Social Networks Analysis

"Our position in this review is that constructivism emerges out of interactions in a virtual community and a social constructivist epistemology underpins the development of social capital in virtual communities" (Daniel *et al* 2003)Two important concepts of *social capital* and *social networks* are rapidly gaining recognition in computer mediated environments to explain relationships individuals create in pursuing their common interests. *Social capital* is an imprecise social construct which emerged from an uncoordinated and unclear terminology, but it is useful for exploring culture, society and *social networks* (Daniel *et al.,* 2003). *Social capital* refers to those features of social relationships, such as interpersonal trust, norms of reciprocity, and membership of civic organizations, which act as resources for individuals and facilitate collective action for mutual benefit (John and MacArthur, 2000). *Social capital* creates value for the connected people, although at times, the benefits may trickle to those unconnected (Putnam, 2000). Putman further states that the best way to create significant change in a community is by

enhancing *social capital* which allows people to resolve their collective problems through cooperating with each other. However, Daniel *et al.* (2003) caution that communities, which display highly cohesive forms of social capital are not necessarily beneficial to a society. They argue that in multicultural societies, where there is a decline in the national political culture, people are closely affiliated to communities but pay close tribal, ethnic, or political allegiances to their own groups rather than national interests. In short, therefore, s*ocial capital* is a process that highlights the importance of personal networks developed over time with the idea of responding to a variety of society's problems, including those experienced in education.

Social networks are communities founded on what people do together rather than where they live with others (Wellman and Gulia, 1999). There is a general understanding that these networks are built out of specific societal need. In the formation of these *social networks*, the cultural background of members is important because it influences networks' characteristics, contents, and structures (King and Waldegrave, 2003). Daniel *et al.* (2003) posit that *social networks* can bridge cultural differences by building a common identity and shared understanding. According to Amory (2005), recently there has been an upsurge of on-line *social networks* such as Orkut (www.orkut.com), Friendster (www.friendster.com), Tribe.net and LinkedIn (www.linkedin.com). It is through nurturing and promotion of these *social networks* that appropriate learning can take place. Through the building of *social networks* in cyberspace, the notion of social constructivism, in particular, collaborative learning is given prominence with emphasis on active exchange of ideas and promotion of critical thinking (Garrison, 1997).

John and MacArthur (2000) identified two major forms of virtual learning environments, resulting from the social capital, namely *virtual learning communities* (VLC) and *distributed communities of practice* (DCP) with the key difference being the nature of membership identity. The VLC is a group of people who gather in cyberspace with the intention of pursuing learning goals (Daniel *et al*., 2002), while the DCP refers to a group of geographically distributed individuals who are informally bound together by shared expertise and shared interests or work and collaboration is their most important shared characteristic (John and MacArthur, 2000). Although, most individuals in VLC often hardly know each other, those in DCP are well known to each other.

There is a need to understand networks and their participants by evaluating their locations in the network (Krebs, 2004). These measures help to determine the importance, or prominence, of a person in the network. Amory (2005) states that the use of *Social network Analysis* (SNA) methods could provide a mechanism to investigate or describe the social interactions in learning

environments. Involved in the SNA are the mapping and measuring of these normally invisible relationships between people, groups, organizations, animals, computers or other information/knowledge processing entities (Krebs, 2004). Bonabeau and Krebs (2002) contend that in analysing the flow of information within any network, SNAs may reveal that people who are supposed to be key to organisations are isolated while anonymous workers hold powerful influence. Krebs (2004) further elucidates that SNA tools such as InFlow, can map and measure teamwork, communication, information flow through the use of the three most popular metrics: *Activity*, *Betweenness* and *Closeness*. A synthesis of these concepts is given by Krebs as below: (i) *Activity:* Social network researchers measure network activity for a node by using the concept of degrees, that is, the number of direct connections a node has. The most active node in the network has the most direct connections to it. However, high level of activity does not make any node (person) more important than the rest as these might be people from the same network (or business). (ii) *Betweenness:* This node has a big influence over what flows in the network even with few direct connections. However, the problem is that this node, being in the middle of at least two networks is a single point of failure. Without this node, some people in the network would be cut-off from the information and knowledge. (iii) *Closeness:* Where two nodes in a network have shortest paths to all others. However, even with fewer connections the pattern of their direct and indirect ties allows them quicker access to others in network.

The concepts of *social capital* and *social networks* are all crucial in virtual learning environments as they allow the formation of learning communities based on mutual goals. With SNAs, the nature of interaction within these communities could be measured to determine whether the relationships are of benefit to all learners.

In the mid-1990, in an endeavour to reconstitute the curriculum which embraced the democratic tenets and norms, the South African government argued that ICT tools could be harnessed to support the introduction of the new curriculum. Margules (1996) says,

> "Those educators and developers favouring the constructivist approach have sought to tap the computational power of modern microcomputers and their associated technologies, to create an environment in which learners can experience and develop sophisticated ideas from a variety of domains".

The two concepts of *social capital* and *social networks* could play a major role in the South African academic environment in that learners located in different areas would be able to form their own communities of learners striving for a specific goal through collaboration.

2.2. CONCLUSION

Over the past 10 years, there has been a greater acceptance of the constructivist model of learning and this is especially useful in environments that support dialogue and conversation using new technologies. It is often argued that in a post-modern world there is a need for a curriculum that engages students in learning as active participants in acquiring their own knowledge. Also, the instructivist theory does not sufficiently address the development of cognitive skills of learners nor provide space for learners to participate actively in knowledge acquisition. Constructivist theory, however, in its many forms allows learners to participate constructively in their learning endeavours by constructing their own knowledge. Therefore, this research is strongly founded on the pillars of constructivism, particularly social constructivism with an emphasis on social activities and culture. The subsequent section investigates the role and the effectiveness of ICTs in the promotion of learning and argues that ICT can only be successfully integrated into classroom practice based on social constructivist pedagogies.

CHAPTER 3
INFORMATION AND COMMUNICATION TECHNOLOGY IN EDUCATION

3.0. INTRODUCTION

The relationship between society, educational practice and technology are complex. Technological advances have often out-paced human ability to socially absorb and effectively incorporate new technologies (White, 2003). This is also true for the use of technology as an educational tool. Today, society is undergoing a transformation from the industrial age to the information age which is having a profound impact on both industry and academia (Edgar, 1999). In the industrial era people depended on transport systems to get people and paper to places where business was conducted. However, society now depends more on telecommunications to move information to where it is needed (Tiffin and Rajasingham, 1995). Where communication was once based on paper transactions and face-to-face meetings in rooms today, with the use of ICTs gathering pace, some institutions are beginning to advocate paper free office environments. The ICTs affect all processes at the centre of all of social life such as social engagement and isolation, community boundaries and bonds, relationships between the advantaged and disadvantaged, citizen involvement in democracy and the accountability of elected officials to the public (CITS, 2001). Therefore, these technologies have changed the way people learn, work, live, and communicate (Jones, 1995).

ICTs are also impacting education practices where they have not only affected the skills that schools and universities must teach students but have also realigned both the relationships between students and teachers and the nature and boundaries of classrooms, schools, libraries, and universities, and the practices of education. The increasing role played by ICTs in the development of society calls for an active reaction to the challenges of the information society (Danish Ministry of Education, 1997). Today, IT is becoming 'mission-critical', a central foundation to the future of higher education (Edgar, 1999).

In the same way that writing managed to do away with oral history in many parts of the world, computer technology is slowly pushing away the power of print technology and the dependence on the textbook, which is linear in both the content and design. "Writing began the long, slow disestablishment of the face-to-face community of people who all knew each other, and every communication technique introduced since then has furthered that process" (O'Donnell, 1995). The ICT environment, however, has established a new educational order where functionality is based on nonlinear modes of navigation and formal education is paramount. The Southwest Missouri State University (2000) states that this transition from industrial to an information-

based economy made possible by information technologies, demands that 21st century workers be equipped with skills to use and adopt these technologies and their ongoing charges. In the new information based economy, the success of any organisation will depend in some part on its ability to leverage information and information technologies. In such a society people should be able to select, arrange, manage and use those sources of data. Thus, powerful tools such as networked computers are going to be important in the transformation of human communication (O'Donnell, 1995). Therefore, in a society becoming increasingly dependent on information and the processing thereof, great demands are placed on individuals who should have a solid and broad educational foundation.

The days of considering technology simply as an enhancement for the instruction of students, a tool for computational academic scholarship, or the means to the efficient operation of the institution are past (Druker, 1994). Druker further contends that there are demands in the IT based society for workers who are different from those of the industrial age in that they have the formal education and have the desire to continuously learn. These demands create serious challenges within the educational sector to provide workers who can function in the new information society. Therefore, the challenge facing higher education is to prepare for this future and to provide a technology-rich environment where students can obtain the continuously changing knowledge and skills needed to shape that future (Edgar, 1999).

Regarding storage and utilisation of information it can be seen that at one time people were required to memorise all information needed, books were invented to store a large body of information but now, books are giving way to computers and other electronic tools as storage systems (Underwood and Underwood, 1990). The ICT environment is appropriate for new forms of learning which support the needs of children disadvantaged by the traditional forms of instruction still dominant at the turn of the 21st century.

In this chapter the relationship between learning and technology is explored in order to better understand such relationships, to provide a theoretical background to the technological choices that are part of this thesis and understand the relationships between educational theories, practices and technology.

3.1. IMPACT OF ICTs ON EDUCATION

Many schools of today were designed to prepare people for life in an industrial society (Tiffin and Rajasingham, 1995) but the problem is that we in South Africa live in a period of transition between an industrial society and an information society. Freire (1973) perceives as an

intellectual challenge the transition from the old paradigm of "teaching as telling" to the new paradigm of "lifelong learning".

> "If men are unable to perceive critically the themes of their time, and thus to intervene actively in reality, they are carried along in the wake of change… Lacking… a critical spirit… man cannot perceive the marked contradictions which occur in society as emerging values in search for an affirmation and fulfilment clash with earlier values seeking self-preservation… This shock between a yesterday which is losing relevance but still seeking to survive, and a tomorrow which is gaining substance characterises the phase of transition as a time of announcement and a time of decision. Only, however, to the degree that the choices result from a critical perception of the contradictions are they real and capable of being transformed in action. Choice is illusory to the degree it represents the expectation of others" (Freire, 1973)

This change illustrates the change in thought and the acknowledgement of capabilities of people to make their own informed choices. Forsyth (1999) in concurring with Freire maintains that without a critical mind the potential for people to participate in change and determine their future is limited to the options offered. They do not have the potential or the chance to contribute or to be proactive in the process of change. The ICTs have been at the core of this transition where computers are increasingly being used as a medium for the delivery of teaching and training; supporting, supplementing or replacing face-to-face learning. The use of computers offers significant advantages over traditional teaching, for example, by providing organised access to many types of resources, more flexible delivery structures and new learning opportunities (Milligan, 1999). The advent of the Internet has also opened other opportunities for delivery of content using computers. Forsyth (1999) sees the Internet as a tool for teachers and learners to use for accessing information which changes the role of both teachers and learners and a source of information. This significantly changes the role of teachers who in a face-to-face course delivery has been the source of knowledge. However, Forsyth argues that the Internet does not change their expertise but changes the way they operate and the skills they need.

3.1.1. The Technologies and Usage

Educational policy in the information society must ensure that each citizen has an active and critical attitude to developments and not passively allow technological development to set the pace (Danish Ministry of Education, 1997). Therefore, there are wide-ranging debates in academia about the role of technology in education (Edgar, 1999). Edgar contends that IT has a comparable impact to that of the printing press in the 15th century. Even though IT has revolutionised change in all aspects of teaching, most teaching is still done in classrooms, by teachers physically present, using blackboards and chalks, textbooks, frequent examinations written on lined paper or blue books (Ruth, 1997). Greenberg (2004) asserts that there are three

competing camps of academics, researchers, and practitioners working in the field of IT: (i) adherents who claim technology improves education; (ii) opponents who hold that technology degrades education; and (iii) those who hold that there is no significant difference — saying that technology per se neither enhances nor harms the business of learning. However, technology itself can have little impact on the actual learning (technology is a neutral agent) but rather it is the use of technology that fosters a specific philosophical approach. Irrespective of one's position, however, these authors agree that IT has opened opportunities for institutions of higher learning to offer their courses on and off campus and that slow changes have been taking place in the last two decades of the twentieth century with educational institutions and academics trying to leverage the promised power of IT.

3.1.2. Cyberspace

The explosive growth of the Internet is indisputable although its significance and effects are contested. Increasingly tools such as World Wide Web (WWW) are incorporated into courses. The ability to use multimedia is emerging as a basic skill which all university graduates must possess in the 21st century (Edgar, 1999). The use of the WWW as an instructional tool has gained momentum as more teachers, instructors, and trainers incorporate it into their repertoire (Mathew and Dohery-Poirier, 2000). It is argued that WWW when used appropriately: (i) can enhance student learning; (ii) allows learning facilitators time to spend with students working in small groups or one-on-one; (iii) reduces repetitive teaching tasks; (iv) reduces paper flow and management; and (v) provides improved instructional materials. Students who use technologies such as WWW, Internet, CD-Rom, audiocassettes, touch screen multimedia training, autodidactic teaching systems for learning spreadsheets and database programming, appear to perform better than those exposed to traditional institutional methods (Ruth, 1997). However, many of these arguments are based on the instructivist mode of learning where technology is seen as tool to provide instruction rather than one to support social constructivist philosophies.

The Vice Chancellor of Melbourne University said that the greatest universities of the 21st century will have geographical locations but will also operate in cyberspace (Taylor, 1993). Cyberspace cannot be understood simply as an efficient tool of communication but as a social space which stimulates new forms of interaction, helps in restructuring and forging new identities, and produces new relations of power, for example, between teachers and learners (Usher and Edwards, 1998).

Cyberspace is having a great impact on the traditional forms of education as it questions the actual foundation of education. For instance, Lankshear *et al.* (1996) when talking about restrictions placed on the learner says that education as a modernist institution is characterised by the 'spaces of enclosure' of the book, the classroom and the curriculum - spaces which work to enclose meaning. The learner's task is then one of extracting a singular canonical meaning and the teacher's that of being the 'authority' in terms of interpretation and accuracy.

Cyberspace, calls all these spaces into question, the fixity and stability of the word, the linear text with definitive meaning, and the teacher as authoritative bearer of meaning. In cyberspace learning, rules are more egalitarian, purpose-driven, self-imposed and self-monitored (Lankshear *et al.,* 1996). This statement supports the assertion made by Featherstone (1995) who contends:

> "Cyberspace creates a reader-controlled environment or at least an environment where the distinction or boundary between readers and writers becomes less clear and consequently textual production and interpretation become less bounded. Hence, learners are more able to determine their own paths of learning where they do not simply interpret pre-given meanings but actively collaborate in its creation. In cyberspace practices, meanings are more readily negotiated by its users".

The existence of cyberspace seems to signify a questioning of traditional educational systems founded upon ideas of centre, margin, hierarchy and linearity, where notions of multi-linearity, nodes, links and networks seem more appropriate (Usher and Edwards, 1998). With this, comes the need to re-think pedagogy in terms of multiplicity, of multiple paths and non-linear forms of learning and teacher-learner transactions. This would seem to suggest more opportunities for learner-centred pedagogies in shifting from teaching to learning. What cyberspace does is to change the way teaching and learning is carried out as it redefines the roles of teachers and students. The teacher-student relationship is also reconfigured since potentially all can be 'experts', given the abundance and availability of information in the sites and networks of cyberspace (Lankshear *et al.,* 1998). The changes in teacher-student relationship inevitably lead to a change in their roles too. The need now is to learn how to access and use information, although this particular role is one that teachers may have to share with learners given that the latter may often be more knowledgeable and skilful in cyberspace environments (Usher and Edwards, 1998).

The availability and accessibility of information may also help release teachers from their traditional role as providers of content to that of making the learning process explicit and transparent, for example, by helping in the framing of questions and ensuring that learners critically interrogate information encountered in cyberspace. In cyberspace, the disciplinary

distinction between knowledge and information becomes difficult to maintain (Usher and Edwards, 1998). 'Legitimate' or 'worthwhile' knowledge becomes that information used in the self-directing and self-monitored practices of cyberspace's virtual communities.

In summary, information technology in particular cyberspace, has opened up the field of education and has provided a foundation for a new paradigm that treats both learners and teachers as active participants in the process of education. The new paradigm can be understood through the emergence of virtual learning environments where focus is moved away from the teacher as the central authority responsible for validating gained knowledge. There is a need to investigate thoroughly how this pedagogic shift helps to enhance education received by learners. Therefore, the next consideration will be on the paradigm shift in pedagogy from face-to-face to interactive learning.

3.2. FROM FACE-TO-FACE TO INTERACTIVE LEARNING

Computer based technology has been at the forefront of many changes in education resulting in a conspicuous shift in teaching and learning. Schools are moving from traditional forms of curriculum where print and classroom are central towards a more interactive learning dominated by new media technology. This shift was first articulated in the early 1960s by Herbert Marshall McLuhan who saw the problems of the traditional school as linked to the shift from a "mechanical age" characterised by fragmentation, specialisation, and sameness to an "electronic age" characterised by wholeness, diversity and, above all, a deep involvement (Meyrowitz, 1996). McLuhan incensed many academics by suggesting that the modes of thinking, behaviour, and social organisation spawned by printing were not natural or everlasting, and that their five hundred years of increasing influence was ending. In the United States, change is seen as one of the driving forces in the expansion of distance and virtual learning: change in pedagogical thinking, change in the communications infrastructure throughout the country, and change in the capacity and functionality of ICTs (Dirr, 1999). This is how these changes are seen:

> "The old classical model of the university where scholarship and learning is pursued for its own sake is fast becoming an anachronism. Post-modern society has lost faith in the grand humanist narrative of education which is pursued for its intrinsic value. Instead, government, employers and students are asking what education can do for them. They are concerned about the capability of university graduates and not about how well 'educated' or socialised they are" (Luckett, 1995).

Hence, there is a push today to design a curriculum applicable to the ICT world, that is, education with practical meaning. Fothergill *et al.* (1987) argue:

> "If you were to be in any school in five years time you should find children learning about and being prepared to live, in a society in which devices and systems based on microelectronics and associated technologies were commonplace and pervasive, and where these technologies may have altered and be altering the relationships between people, and between individuals and their work".

This change is a direct consequence of education led by the ICTs. There is nothing new about teaching with technology but what is new is the end of a long age of relatively stable technological relations (O'Donnell, 1995). O'Donnell contends that our institutions have long emphasized the autonomy, the authority, and the self-reliance of the teacher in the classroom but we now live in an age when the isolation of the classroom is breaking up and disappearing. This is the end of an era which has been dominated by print and the dawn of the new one dominated by ICTs. Chou *et al.* (1993) discusses these two paradigms, (i) traditional (modern) school and (ii) the virtual (post-modern) school.

3.2.1 The Traditional (Modern) School

The traditional school is based on the traditional theory of teaching and learning. According to Luckett (1995) the traditional model or paradigm has been variously described as 'curriculum as prescription' (Goodson, 1994), didactic model (Rowland, 1993), instructional model (Jenkins and Walker, 1994), or as 'curriculum as product' (Grundy, 1987). Chou *et al.* (1993) argued that classroom education is structured to allow a single teacher the ability to manage a group of students where each lesson occupies a specific amount of time and allows subjects to be divided into units and study is therefore, a sequence of units; progress through stuffy units is regulated and takes no cognisance of learner needs; and learning is structured around the authority of the textbook and excludes the life experiences of students.

McClintock (1996) asserts:

> "Traditionally, the school and the classroom have been places where teachers and students are isolated from the general culture and where information and ideas have been relatively scarce – the textbook is a meagre selection of what a field of knowledge comprises, a skilled teacher is a bundle of ignorance relative to the sum of learning, and a school library a sparse collection at best".

Although the newly introduced C2005 in South Africa is trying to move away from the instructivist practices of the past, the traditional paradigm has been the dominant teaching and learning paradigm in South Africa for centuries and moving away from it is not easy, particularly for teachers who are so used to such practices.

3.2.2. The Virtual (Post-Modern) School

The introduction of virtual learning spaces in the virtual or post-modern school brought changes in the teaching profession (Chou *et al.,* 1993). Differences in access between traditional and virtual learning are highlighted in this manner, "In our extended present, the educational problem changes profoundly, shifting from stratagems for disbursing scarce knowledge to finding ways to enable people to use unlimited access to the resources of our cultures" (McClintock, 1996). The emphasis on student inquiry introduces elements of unpredictability and disturbs any possibility of the routine in the educational discourse. Responding constantly to questions emerging from students' experience, teachers will re-assume the Socratic mantle and reverse the progressive de-skilling the profession has undergone since the Industrial Revolution (Chou *et al.,* 1993). Chou and colleagues table the following characteristics of the virtual learning school: Learning, supported with ICT, can take place independent of time and space; learners are able to gauge their own progress through the learning tasks and can undertake their own investigations; learning design follows a non-linear model; and learning includes the exploration of information other than just a textbook:

> "New media alter the ways of knowing and the opportunities for participating in the creation of knowledge. Multimedia, and its extension in virtual reality, is not merely a glitzy vehicle for edutainment hype. It is an epistemologically interesting development in our culture. … Multimedia make it increasingly evident that the work of thinking can take many forms – verbal, visual, auditory, kinetic, and blends of all and each" (McClintock, 1996)

It appears that these two paradigms (Modern versus Post-Modern result from two dissimilar historical eras influenced by the different technologies and learning theories. While the South African government has embraced a post-modern paradigm through the introduction of OBE, little attention has been made on the use of technology to support both teachers and learners cognitive development.

It is not easy, however, to define post-modernity theory as it means different things to different people. Post-modernism could be traced back to the Renaissance period but became more concrete during the European Enlightenment era of the 19th and early 20th centuries (Klages, 2003). Post-modernism is more of a critic to the notion of modernity which supports "objective knowledge, or the possibility of objective knowledge, by its assumption that such knowledge refers directly to an objective reality which would appear in the same way to any observer" (Lemke, 1994). In contrasting the two concepts, Lemeke asserts that post-modernism denies the presence of 'objective knowledge' as it recognises that knowledge is made through language and other cultural resources of a particular culture, which might be different from culture to

culture and even within groups. Therefore, post-modernity is a theory that espouses multi-pronged approach to learning and acknowledges that there are no absolute truths and or objectives because different cultures can see, and make sense of the world different ways.

It is acknowledged that the information and communication revolution influences concepts such as post-modernity where 'isolate individual worldviews' are now more easily discussed in open and dynamic environment. The question for educationists is how to use the power of ICTs to support multiple worldviews and non-linear learning models. The next section explores the use of virtual learning spaces and educational games.

3.3. VIRTUAL LEARNING SPACES

The previous sections gave an overview of the opportunities provided by technology and made available to education. One of those opportunities opened up by ICTs is that of providing learning in virtual space. The growth of the Internet and the Word Wide Web, in particular, are attracting the attention of tertiary educational institutions worldwide. This could be seen in the increasing number of distance education courses being offered in this medium (Pagram and McMahon, 1997). Electronic material are significantly less expensive to produce, update and access than those in printed form as these have to be reproduced in multi-copies for wider distribution and access (Eklund *et al.,* 1996). These reasons, combined with the cost savings of a 'virtual campus' in real estate and contact time for the university, are leading to the Web being seen as an effective alternative to traditional face to face modes of education. It has been argued that students do not like to learn at a distance (Simonson, 1997), but the convenience and flexibility of an external mode of delivery for those with busy life styles is making distance education an attractive proposition for many prospective students (Truman, 1995). Experience however, indicates that this promise may not be true as the conceptualisation and development of such resource is complex.

3.3.1. The Notion of the Virtual Reality

The phrase virtual reality has its origins in the development of glide simulators for training, it emerged as a distinctive area of computer interfaces and applications in the 1980s (Rheingold, 1991). The term 'virtual' was coined by Jaron Lanier, one of the developers of the first immersive interface devices (Hall, 1990). In the past decade or so there emerged a set of educational technologies called virtual realities (Helsel and Roth, 1991). Other terms such as virtual world, virtual environments, and cyberspace are used as global terms to identify this technology (McLellan, 1996). However, Wheeler (1991) argues that virtual environment is a

more appropriate term than virtual reality. Virtual often denotes the computer generated counterpart of a physical object: a "virtual room", a "virtual glove", a "virtual chair", etc. (McLellan, 1996).

Definitions of virtual reality (VR) evoke a feeling of immersion, perceptual and psychological sense of being in the digital environment presented to the senses (McLellan, 1996). Furthermore, VR provides a degree of interactivity that goes beyond what can be found in traditional multimedia programmes. Jacobson (1993) defines VR as a class of computer-controlled multi-sensory communication technologies that allow more intuitive interactions with data and involve human senses in new ways. Jacobson says that VR can also be defined as an environment created by the computer in which the user feels immersed in the present. The virtual world is interactive as it responds to user's action. For example, with a virtual world one can go anywhere and explore any point of view. The sense of presence or immersion is a critical feature distinguishing VR from other types of computer applications (McLellan, 1996). Virtual reality provides a developmentally flexible, interdisciplinary learning environment (Bricken, 1991).

Virtual reality supports hands-on learning, group projects and discussions, field trips, simulations, and concept visualisations, all successful instructional strategies. McLellan (1996) asserts that VR appears to offer educational potentials in the following areas: data gathering and visualisation, project planning and design, design of interactive training systems, virtual field trips, and design of experiential learning environments, and many more. For effective learning there is a need for properly designed virtual learning environments.

3.3.2. Virtual Learning Environments (VLEs)

Internet technology has developed as a tool which incorporates in its repertoire compressed graphics, audio and video files, which are useful to make learning environments interesting and entertaining to interact with. Hence Truman (1995) argues that compression technologies combined with improved computer speeds at reduced costs are making access to interactive, multimedia instruction readily available to the desktop. In support, Klingenstein (1998) asserts that the delivery of content is an important component of virtual learning but the delivery of the atmosphere, the nurturing of inquiry and the building of a community of learners is equally critical. In order to provide learners with the environment that enables learning different institutions have tried to build their own learning spaces. Depending on their view of a learning space, different institutions have different views on what it is and how it functions. For

example, virtual learning takes place on the Internet which removes the ability of students to raise their hands to ask questions (Alberta Government, 1996). Email and conferencing software replace the traditional question and answer model but both students and teachers need to realise that feedback is not instantaneous. Amory (2000) in the project document of The Virtual Learning Space (VLS) project of the University KwaZulu Natal includes among others, learning through games. Amory (2000) argues, "The successful use of technology in the classroom requires the development of learning environments based on modern educational theory". These examples illustrate that because virtual learning is based on technology its success depends on the technology used. Klingenstein (1998) in describing this more accurately contends, "Almost all pedagogy conceived under the rubric of virtual learning seeks to leverage information technology and so requires the implementation of powerful and readily accessible computer and networking systems". Alberta Government (1996) explains that the effectiveness and efficiency of a virtual learning system are determined by the degree to which it adheres, but not exclusively, to the principles that, the learner is the centre of the learning system, and the soft and hard infrastructures are well integrated to provide seamless access to services and technologies.

Therefore, the ICTs have made it possible for institutions to provide virtual courses in virtual classrooms. The virtual classroom has characteristics which are different from those of the traditional classroom. These characteristics by their very nature change the relationships between students, teachers and institutions. The virtual classroom environment is always available; is flexible and therefore can support unstructured learning activities, collaboration and small-group discussions; and requires a live facilitator to guide, support and initiate learning (WIT, 2000)

Coupled with a need to help deliver content in a virtual learning environment (VLE), is the question of how technology can provide the broader environment that is necessary for effective learning. Virtual Learning Environments are software systems or packages which are used to support learning and are Internet or intranet based (Britain and Liber, 1998). According to these authors, learners and teachers both have similar views of the system but tutors have additional tools and privileges that allow them to add materials, create conferences and track students' progress. In a few cases students have areas for conversation that is private from the tutors' view. VLEs include notice-boards, course outlines, e-mail, conference tools, class lists and homepages, assignments, assessments, synchronous collaboration tools, multi-media resources, file upload areas, calendars, search tools, book-markings and navigational models. A large number of education and commercial VLEs are available. Commercial VLEs are: WebCT

(http://www.webct.com), TopClass (http://www.wbtsystems.com), Virtual-U (http://www.vlei.com), Blackboard (http://www.blackboard.com), Web Course in a Box (http://www.madduck.com/wcbinfo/info.html), etc. Higher Educational institutions VLEs are: ARIADNE (http://ariadne.unil.ch/tools/), CoMentor (http://comentor.hud.ac.uk/), CoSE (http://www.staffs.ac.uk/COSE), etc. There has also been an increase in the availability of Open Source systems such, Moodle (http://moodle.org/) and the Open Learning System (http://www.ols.ac.za).

The VLEs gave rise to usage of different types of learning methods and helped to remodel educational systems. Alberta Government (1996) uses the following criteria to define virtual learning environments:

(i) They are created when distance, information and telecommunication are used to provide educational services which transcend barriers of time and place associated with traditional lecture-type teaching;

(ii) They are supported by a virtual learning system which is composed of two co-dependent infrastructures: a services support network (soft infrastructures which include educational products, instruction, and learner services) and an electronic network linking learners and educators with services (hard infrastructures which include sending, receiving and carrier technologies);

(iii) They serve individuals and groups, facilitate synchronous (same time) and asynchronous (different time) learning, and provide educational services which can be accessed from homes, institutions, communities and workplaces;

(iv) They provide opportunities for learners to increase their participation in the management of the learning process, often creating changes in the relationship between teachers and learners; and

(v) They challenge educational organizations and bureaucracies to modify or remove formal and informal restrictions which have traditionally limited learner access and institutional responsiveness, e.g. transferability, geographic and programmatic jurisdictions, attendance and residency requirements.

Students are, hence, seen as the primary beneficiaries of VLEs. Consequently, the following points summarise the main characteristics of VLEs: (i) Flexiblility of time and place, (ii) Easy to cope with increased student numbers, (iii) Easy to share and re-use, (iv) Enhance collaborative work, (v) Central to student-centred learning, (vi) Helpful in reducing the administration burden, and (vii) Enhance asynchronous learning networks. All these features

support social constructivist practices. The following section will investigate some of the online course models which could be employed in the delivery of course material.

3.3.3. Models of Online-Courses

Mason (1998) proposed a simple framework for categorising online courses as described below which provides a basis for VLEs.

(i) Content-Support Model: it relies on the separation between course content (which is probably delivered in print or possibly now as a course package on the Web) and tutorial support (which in its simplest form is delivered by email or alternatively by computer conferencing). It involves a low level online interaction and not more than 20% of student's time.

(ii) Wrap-Around Model: these are courses which consist of tailor made materials (study guide, activities and discussion) wrapped around existing materials (textbooks, CD-ROM resources or tutorials). This is a 50/50 model because the online interactions and discussions occupy about half of the students' time, while the predetermined content occupies the other half. A wrap-around model could make use of centrally written and held materials but critically, some part of the learning would come through online discussions and collaborative activities.

(iii) The Integrated Model: this is a resource based model where the course is defined by collaborative activities, discussions and joint assignments and it relies on active learning. The course contents are fluid and dynamic as they are largely determined by the individual and group activity. The interaction is asynchronous and not face-to-face. Assessment of students' work is very important. Both staff and students are pro-active. The educational approach is less pre-structured and more responsive to students' requirements.

3.3.4. Weaknesses of VLEs

Although VLEs are an important component of the new educational paradigm they too have their own weaknesses. According to Lee *et al.* (1999) these weaknesses include:

(i) Flexibility over time. Whilst VLEs have great benefits, they can also create problems for participants as it may be days, depending on the level of activity within an environment, before someone replies to a question as people are not in the environment at the same time.

(ii) Decision making. This can be difficult again due to flexibility over time and the notion that everyone can have their say in this environment.

(iii) Access to a computer and the Internet. This can hinder progress if access is not available.

(iv) IT literacy. There is a need for a certain level of technical competence to overcome any difficulties which may arise from accessing these environments.

(v) The level of discourse. This may differ with the system. For example, students would not be expected to communicate in a 'virtual café' in the same way that they would in an on-line tutorial. Sometimes these levels of discourse can be at odds as people continue in an informal way in a more formal area.

Diversity University (1997) raises other weaknesses and says that VLEs: (i) require instructors or supporting staff to research the available tools in what is a rapidly changing area; (ii) provide many different user interfaces for the instructor and possibly the students to learn; and (iii) may not provide for referencing and linking across materials of different types that are accessed using independent software applications.

Other weaknesses according to O'Leary (2002) could be put into the weaknesses of technology and weakness of usage. With respect to technology O'Leary (2002) argues that virtual learning technologies can become a 'dumping ground' for materials not designed to be delivered online; copyright and intellectual property rights (IPR) of materials need to be considered; off campus access to hardware and networks can be problematic for both students and educators and this can raise issues of equality in terms of access; the disability legislation and accessibility to online materials also need to be considered; there is a need to plan online support carefully to avoid overload; and such independent learning still needs to be guided and supported for both students and educators. O'Leary (2002) also argues that Internet-based communication have many technical problems. This idea is supported by Paechter (2000) who argues that since communication in VLEs is largely text-based (although increasingly new systems support multimedia), there is a lack of expressive non-verbal cues which enhance what is being said, and in particular the way it is being said. For example, video-conferencing systems cannot simulate the conditions of a face-to-face situation because important variables such as body space or eye contact are not properly transmitted. Also, phenomena such as de-individuation in the sense of socially inadequate behaviour, excited and uninhibited communication such as flaming (insults, swearing, hostile, intense language), greater self-absorption versus other-orientation, and messages signalling status equalisation may occur. These systems, therefore, do not create the same atmosphere of social intimacy as face-to-face interactions.

Notwithstanding these weaknesses, VLEs are an important integral part of the new educational paradigm. The work that is being done to enhance the quality of the different VLEs spurs

educators to put more effort in designing good quality learning environments for the benefit of learners.

3.4. COMMUNICATION MODELS

Transmission of messages is another important tool which is rarely given a thought in the instructional technology discourse. A number of communication models try to explain how information moves from sender to receiver. In 1949 Shannon and Weaver designed the best-known model. In this model, a message emanates from an information source and a transmitter converts it into a signal or series of signals (Hawkridge, 1983). During transmission, noise may be produced 'noise', that is, various kinds of unwanted interference making it difficult for the receiver to accurately decode the original message. Fournier (2002) simplified this model as;

> Suppose you have an idea in your head (information source) that you want to tell someone about. You must first move the idea from your brain to your mouth (transmitter). Since you cannot actually share your grey matter, you must select words for your transmitter to use. Once you speak, your voice (signal) is carried through the air toward the listener's ear (receiver). Along the way, your signal is joined by a myriad of other sounds and distractions (noises). The receiver then takes everything it receives and tries to maximum the message and minimise the noise. Finally, the receiver conveys its message to the other person's mind (destination).

The model was dominant until the early 1980s (Hawkridge, 1983) but its demise was brought about by simplicity and obviousness which portrays communication as a linear action with a beginning and an end, a source and a destination (Tiffin and Rajasingham, 1995). It is noted that, although Shannon and Weaver's work was very fertile in fields such as information theory and cybernetics, it may actually be misleading in the study of human communication. In this model, communication is reduced to a question of transmitting information. Shannon and Weaver's model is a one way model, based on engineering (Hawkridge, 1983) which, to a certain extent, is appropriate for unidirectional modes of communication such as television and radio. To convert Shannon and Weaver's model into a two-way model of communication a feedback channel must be added (Hawkridge, 1983). This channel must include transmitter, encoding, noise, decoding and receiver, all to deal with messages returning from the receiver to the sender. Besides being criticised as being too linear because it accounts only for the act of sending and receiving, it is argued that this model is not suitable for information society as it does not take cognisance of the two-way nature of computer based communications interactive in nature.

Another criticism levelled against Shannon and Weaver's model, important as it was when it was first published, has been that it did not provide for the complex nature of relations among

humans. In fact, it is Wilbur Schramm's model of 1954 which places greater emphasis on the processes of encoding and decoding. It is misleading to think of the communication process as starting somewhere and ending somewhere because it is really endless (Schramm, 1954). The Osgood and Schramm circular model is an attempt to remedy that deficiency. The model emphasizes the circular nature of communication. The participants swap between the roles of source/encoder and receiver/decoder. This circular model reminds us that receiving a message is not simply a matter of decoding, but also of interpreting the message.

Hawkridge (1983) suggested a model that could help to explain the functions of new information technology. Hawkridge contends that this model must first be a two-way model - with channels allowing for two-way traffic. Secondly, it must include all the functions and, thirdly, it must show how these functions are integrated. Ideally, it should also exhibit the complexities of both human-human and human-machine interaction. Bearing these models in mind Berlo (1960) suggested that there are five verbal communication skills divided into three groups: the first group are encoding skills as found in Shannon-Weaver's model (i) speaking and, (ii) writing. Shannon and Weaver proposed the second tier which deals with decoding skills called decoders (iii) listening and (iv) reading. The third group is promulgated by Berlo, is crucial to both encoding and decoding, and (v) it deals with thought or reasoning. Berlo's suggestion concurs with the notion of constructivism which is supported by the new ICTs.

3.5. OTHER COMMUNICATION ASPECTS

In the 1980s and early 1990s a field of study emerged which was concerned with intrapersonal, interpersonal, grouped and cultural communication in classroom settings. Although not much research was done, classroom communication studied verbal and non-verbal (Hansford, 1988) communication in the classroom. Given the potential of ICTs, it is important to determine whether there is any communication system for learning which is better designed to promote equal participation, visual and literacy skills or other aspects of human endeavour. The encouragement and nurturing of culture of communication need to be part of learning and be supported at home, in schools and in other public institutions. The Internet and ICTs have increased the capacity of individuals to generate and manipulate knowledge, and to communicate ideas and values quickly, irrespective of geographic distance (Allison, 2000). Fischer (1998) says that workers can now communicate with the company CEO by email without having to traverse the chain of command, and students are able to access a wealth of information on-line as well as communicate directly with their professors at any institution in the world. Thus, ICTs have created spaces to allow expression of different opinions regardless of people's economic, social and cultural backgrounds. This augurs well with the theory of

constructivism as discussed in the previous chapters. This concurs with certain understandings of democracy, particularly in the classroom, which give learners their rightful place of contributing to their own learning. If a person possesses any tolerable amount of common sense and experience, his own mode of laying out his existence is the best, not because it is the best in itself, but because it is his own mode (Mill, 1859). Therefore, communication is an important aspect of the new school led by ICTs.

3.6. CONCLUSION

In this section the power of ICTs to open doors for learners, teachers, and curriculum designers for the provision of education that is learner centred was explored. The potential of ICTs to overcome both the constraints of time and space in order to provide a learning space was emphasised. That is, physical space and synchronicity are no longer important elements for acquiring knowledge. The role of theory in the acquiring of knowledge was also discussed. The importance of the theory of constructivism as a provider of a voice to learners by allowing them to participate actively is highlighted. However, Reeves *et al.* (2004) argue that today the development of collaborative online learning communities is not to do with technology, but much more to do the conceptualization of such learning environments and the methods used to investigate the use of ICT in education. In the next chapter the role of computer games, which could be viewed as a meaningful and interesting way to integrate ICT and learning, as a medium for education and as a platform of communication between learners and teachers, is explored.

CHAPTER 4
COMPUTER GAMES AND PLAY IN EDUCATION

4.0. INTRODUCTION

From the beginning of time games have always played a fundamental part in the lives of people. Games are always played to achieve a certain objective. Fortunately, with the changing times and the emergence of ICTs and the strengthening of constructivist methods of teaching games have claimed a new status in education. This chapter will discuss this new role of games and play in education.

4.1. THE ROLE OF PLAY AND COMPUTER GAMES IN EDUCATION

The emergence of the computer as an important tool of education coincides with the current perspective of effective instruction in which meaningful learning depends on the construction of knowledge by the learner. However, the use of games and simulations in education is well documented in history and in the recent literature. They have been used in preschool, K-12, the university, the military, business, and by older adults (Dempsey *et al.,* 1997). The different historical events, such as the advent of the industrial age at the turn of the 20th century or the impact of World War II, all have had a tremendous influence on what a society's citizens think education should be (Rieber, 1996). In the 1950s, in the United States, the use of games and simulations emerged on the educational platform but the advent of the basic-skill movement led to its decline (Gredler, 1996). Recent studies show that with the emergence of ICTs, the role of computer games in education has gained momentum and is continuously being re-evaluated (Rieber, 1996). Rieber opines that it is surprising that play, one of the most fundamental and important aspect of human interaction has received so little attention from researchers. It is often asked whether play aspects could be combined with instruction to enhance learning (Randel *et al.,* 1992). Play is part of the learning process and simulation and adventure games, constructed as microworlds, could be used as viable educational tools (Amory, 2001). Research shows that many students enjoy playing games resulting in a change of attitude toward the role of games in education. The increased power and flexibility of computer technology has also contributed to renewed interest in games and simulations (Gredler, 1996). Amory (2000) stresses that the advent of computers coupled with superior graphics has led to the explosion in game software.

The concern with playing games has led educators to explore the feasibility of using a game format to supplement or replace the teaching of a variety of subjects. Randel *et al.* (1992) maintain that even with this realisation of the importance of play not much research on the

educational effectiveness of games has been undertaken and point out that most recent evaluations of educational software have examined characteristics of the games rather than learning effects. In addition, Gredler (1996) observes that most studies, which address games and simulations, do not document the ways in which students interact with the subject matter and each other during a game or simulation. The weakness of most studies is that they compare simulations to regular classroom instruction although their instructional goals for which each can be most effective often differ. "The lecture method is likely to be superior in transmitting items of information. In contrast, simulations have the potential to develop students' mental models of complex situation as well as their problem-solving strategy" (Gredler, 1996). Gredler says that games and simulations are often referred to as experiential exercises because of the unique opportunities they provide to students for interacting with knowledge domains. Games are defined as competitive interactions bound by rules to achieve specified goals that depend on skill and often involve chance and an imaginary setting (Cruickshank and Telfer, 1980). Regarding play Rieber (1996) argues

> "In one era, play can be viewed as a productive and natural means of engaging children in problem solving and knowledge construction, but in another era it can be viewed as a wasteful diversion from a child's studies... Perhaps most important is the relationship of play to achieving educational outcomes".

Three forms of play were identified depending on the type of activity students get engaged in and the type of tools they use: games, simulations, and microworlds. Gredler (1996) in differentiating between games and simulations mentions two main concepts which are important in their analysis: surface structure and deep structures. The analysis is based on the works of Van Ments (1984) who defined the surface structure as the paraphernalia and observable mechanics of an exercise, for example, drawing cards, moving pieces around the board, etc. The deep structure refers to the psychological mechanisms operating during the course of the event. The deep structure of games and simulations transport players (game) or participants (simulation) to another world and are both environments in which students are in control of the action. For example, within the constraints established by the rules, game players plan strategy in order to win, and in simulation participants undertake particular roles or tasks in order to manage an evolving situation such as managing a business or designing and managing research projects on generations of generic traits. Computer simulations can have several instructional functions, ranging from simple training devices for procedural skills over purely illustrational means up to the curricular introduction of subject matters which, due to their complexity and abstractness, could not yet be dealt with in education (Leutner, 1993).

Within the realm of the deep structure Gredler (1996) explains the differences between games and simulations by arguing that games are competitive exercises in which the objective is to excel by winning. Players compete for points or other advances which indicate that they are outperforming other players. In simulations, however, participants do not try to win, but take on either demanding, responsible roles such as concerned citizens, business managers, interplanetary explorers, or physicians; or professional tasks such as exploring the causes of water pollution or operating a complex equipment system. This characteristic of simulations is referred to as "reality of function".

Another difference, although this is challenged by new computer games, is that the event sequence of a game is typically linear, whereas a simulation sequence is non-linear. The player or team in a game responds to a stimulus, typically a content-related question and advances or does not advance depending on the answer. This sequence is repeated from each player or team at each turn. In a simulation, however, participants at each decision point face different problems, issues, or events that result in large measure from their decisions. Gredler calls this feature branching. Games also consist of rules that describe allowable player moves, constraints and privileges, and penalties for illegal actions. In contrast, the basis for a simulation is a dynamic set of relationships among several variables that change over time and reflect authentic, causal processes. For example, in diagnostic simulations in which the student is managing the treatment of a patient, the patient's symptoms, general health characteristics, and selected treatment, all interact in predictable ways. Most games are computerised, whereas most simulations are not (Randel *et al.,* 1992). Therefore, these types of games and their importance to learning are discussed below.

4.1.1. Simulations

Simulation models a process or mechanism relating input changes to outcomes in a simplified reality that may not have a definite end point (Randel *et al.,* 1992). Simulation games are often used in educational environments where students can focus on a single goal (Amory, 2001). Simulation usually serves one of two purposes: scientific or educational and in both cases, there are usually some inherent reasons why the actual system should not be experienced directly, such as cost, danger, inaccessibility, or time (Rieber, 1996). A simulation is any attempt to mimic a real or imaginary environment or system (Alessi and Trollip, 1991). A simulation is determined by the content or domain it seeks to model and is usually judged on the basis of its fidelity to the domain (Alessi, 1988). For example, most flight simulators could not be

considered microworlds because many people would not comprehend how they work. Several characteristics of simulations are, however, relevant to the design of microworlds.

4.1.2. Microworlds

Another design artefact consistent with play is the constructivist idea of a microworld which is "a small, but complete, version of some domain of interest" (Rieber, 1992). Rieber declares that at first glance, computer-based microworlds are often confused with simulations. People do not merely study a domain in a microworld, they "live" the domain and this is similar to the idea that the best way to learn Spanish is to go and live in Spain. Microworlds are found naturally in the world or are artificially constructed. A child's sandbox is a classic example of a natural microworld; given buckets and shovels, the sandbox becomes a volume and density microworlds for the child (Rieber, 1992). In contrast, artificial microworlds model some system or domain for the user. Microworlds have two important characteristics that may not be present in a simulation (Rieber, 1996). First, a microworld presents the learner with a simple case of the domain, even though the learner would usually be given the means to reshape the microworld to explore increasingly more sophisticated and complex ideas. Second, a microworld must match the learner's cognitive and affective state. Learners immediately know what to do with a microworld – little or no training is necessary to begin using it. This is in concert with the constructivism theory. For example, no training is necessary for the child to use a sandbox. Rieber (1996) contends:

> "In a sense, then, it is the learner who determines whether a learning environment should be considered a microworld since successful microworlds rely and build on an individual's own natural tendencies toward learning. Therefore, it is possible for a learning environment to be a microworld for one person but not for another".

The dominant characteristic of microworlds is that learners are expected to self-regulate their own learning in a microworld (Rieber, 1996). Self-regulated learning is when a person takes responsibility for his or her learning and, as a result, takes appropriate action to ensure that learning takes place. Zimmerman (1990) points out that self-learning has three main characteristics: (i) Learners find the environment to be intrinsically motivating, that is, they find participating in the activity to be its own reward and do not seek or need external incentives; (ii) Self-regulated learners are meta-cognitively active and learners actively engage in planning and goal-setting and are able to monitor and evaluate their own learning progress; and (iii) Self-regulated learners are behaviourally active in that they take the necessary steps to select and structure the environment to best suit their own learning styles.

Motivational researchers have offered the following characteristics common to all intrinsically motivating learning environments: challenge, curiosity, fantasy, and control (Lepper and Malone, 1987; Betz, 1996). Although a simulation may be designed as an expandable simple case of a system that appropriately matches a learner's prior knowledge and experiences, this, in and of itself, does not satisfy the requirements of self-regulated learning. The learner may not be interested in choosing initially to participate in the activity or may not choose to persist in the activity for extended periods of time at a meaningful level (Randel *et al.,* 1992).

4.1.3. Games

Games offer many advantages as they have the potential to meet most, if not all, of the characteristics of intrinsic motivation (Rieber, 1996). Rieber goes on to suggest that games offer an organisational function based on cognitive, social, and cultural factors all related to play. They can be designed for both children and adults with clear and simple goals but with uncertain outcomes. The utility of gaming as a microworld design tool goes well beyond its inherent motivational characteristics. They also become models or enactments of real-life dramas (Roberts *et al.,* 1959). According to this theory, games provide a socially acceptable means of rehearsing the necessary skills and anxieties that may be needed later in real life. Anthropologists have long viewed games as one aspect of expressing culture, or of people demonstrating their psychological dispositions (Rieber, 1996). However, playing a game successfully can require extensive critical thinking and problem-solving skills (Randel *et al.,* 1992). There is an attraction toward a game which needs to be satisfied in order for students to engage in meaningful play. Provost (1990) lists a number of attributes of play as: usually voluntary; intrinsically motivating, that is, it is pleasurable for its own sake and is not dependent on external rewards; involves some level of activity, often physical, engagement; and distinct from other behaviour by having a make believe quality.

According to Gredler (1996) academic games should meet two requirements: First, chance or random factors should not contribute to winning. Second, winning in academic games should depend solely on the application of subject-matter knowledge and/or problem-solving skills and advancement in the exercise should be based on academic skills. Therefore, Gredler argues that academic games should be used for such purposes as: to practice and/or refine knowledge/skills already acquired, to identify gaps or weaknesses in knowledge or skills, to serve as a summation or review, and to develop new relationships among concepts and principles.

Unlike most classrooms which are highly competitive, with individual students competing for scarce reinforcements (De Vries and Edwards, 1973) another aspect of educational games is their role in team building. Roberts (1976) while supporting simulation games contends that their lack of competition allow students to explore or experiment at their own pace. Nonetheless, games that involve teamwork depend on the performance of all team members, and this introduces a cooperative task structure within teams and increases the availability of reinforcement. Again, the cooperative nature of game structure reinforces peer tutoring and cooperative learning during practice sessions (Gredler, 1996).

The role of play in learning cannot be overemphasised as games provide an effective learning environment. However, a properly designed game, which is cooperative in nature and constructivist in philosophy, is of paramount importance to learning. Educational games could be viewed as instruments that promote the use of modern educational theories in the classroom (Amory, 2001). This is fundamental as learners are expected to construct their own learning. Presently, the democratisation of the classroom and learning itself are major focal points that need addressing by educationists. Amory further states that many computer games are not developed by instructional designers and, therefore, inappropriate for learning. This was also previously observed by Vargas (1986) who realised that students using computer software encounter problems with computer games in both game mechanics and principles of instructional design. In many instances, the game mechanics problems include inappropriate vocabulary for students, inadequate directions, lengthy texts, and multi-step directions with no opportunity for student practice and inappropriate directions and inappropriate use of graphics. Many game mechanics do not provide options for students to bypass tasks that are too complex or bypass items they are unable to answer. Therefore, well designed interactive and intrinsically motivating games are paramount to good learning habits.

4.1.4. Weaknesses of games software

The weaknesses of games software have been clearly raised by many role players and stakeholders in the educational games industry. The following are the weaknesses and shortcomings of many games software as eloquently expressed by the British Educational Communication and Technology Agency (Becta) (2004):

(a) It is often difficult to design epistemic games at the right level of interest and challenge for the user. Games may be too easy or too difficult to play, with a decrease in motivation in either case.

(b) Games are not universally well designed and are subject to the generic software problems of a confusing interface, insufficient feedback for the user and illogical rules or constraints within the game.

(c) Much games software is gender specific. Males and females seem to prefer different styles of games. Some games software is successfully marketed for girls. However, from the players' point of view, it seems that while 'female' software is for girls only, ‘male’ software is for everyone.

(d) Many games have a high element of violence. The roles game players adopt may require or satisfy the need for aggression and extreme control seeking. Because there is no opportunity for reflection on this 'behaviour' during or after the game, aggression and violence are implicitly condoned and indeed seem essential.

(e) Many computer games are designed for single users and that collaboration may be entirely superficial. Players may collaborate by taking turns, or by giving one another advice, but this collaboration is not educationally effective. Therefore, there is a need for games involving more than one player: multi-user interfaces and shared spaces to facilitate collaboration, either synchronous (interactive) or asynchronous.

To overcome the short-comings raised by Becta, Amory (2001) and Amory and Seagram (2003) have developed a practical framework to support the design and development of educational games where educational theories are tightly integrated into the game design process. The Game Object Model (GOM) (Fig. 4.1) consists of a number of spaces, which are described by both abstract and concrete elements (interfaces). The abstract interfaces of play, exploration, challenge and engagement are associated with the outer container, the Game Space, which contains the Visualization Space. A single concrete interface (story line) and a number of abstract interfaces (critical thinking, discovery, goal formation, goal completion, competition and practice) are part of the Visualization Space which contains the Elements and Problem Spaces. The Elements Space which includes the Actor Space realize the abstract exploration and engagement interfaces through the concrete interfaces of graphics, sound, technology, interactions and gestures. The Problem Space realizes all the abstract interfaces of the Visualization Space. According to Amory and Seagram (2003), games can be visualized as the interlinking of three aspects: the story, the problems and the graphical realization of the story and problems.

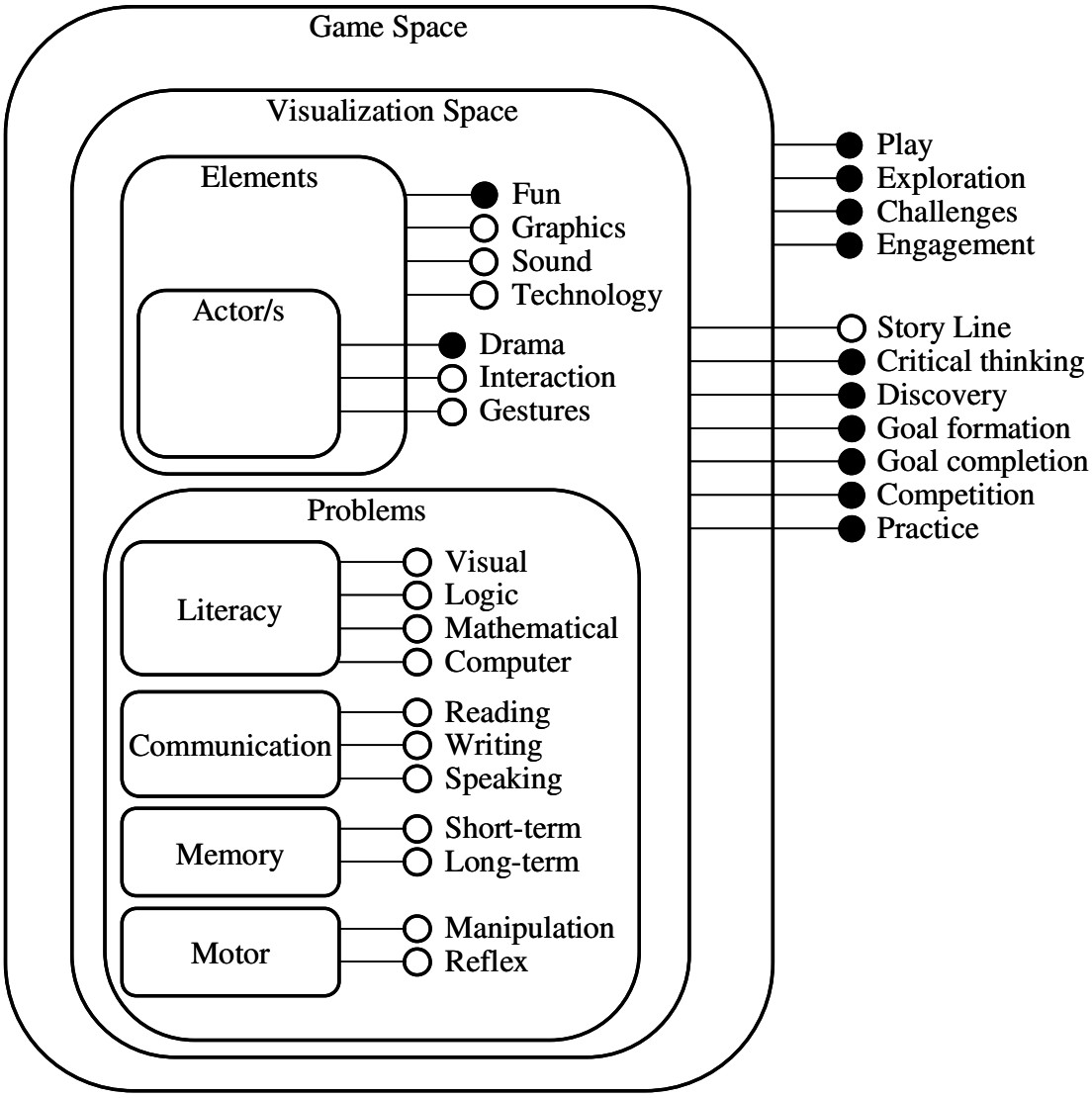

Figure 4.1. Game Object Model (from Amory and Seagram, 2003).

Associated with GOM are the Game Achievement Model (GAM) which provides a mechanism to design education games and the Persona Outlining Model (POM) used to describe a typical game player or target audience (Amory and Seagram, 2003). "This model more broadly defines the ways in which games should be based on pedagogy whereas the Game Achievement Model rather defines more specifically how such games can be designed" (Seagram, 2004). Again, this model attempts to evaluate learners' skills after playing games by examining the impact of play on problem solving skills such as literacy, communication, memory, etc. However, while much work has been done on the design of educational games, not much is known on the impact of such tools on learning and educational practices.

4.2. RESEARCH PROBLEM

The primary objective of this study was to determine the educational value of games designed using the GOM with learners from a wide range of backgrounds. In order to realise this objective it was necessary to first design a research instrument that could be used to describe learners in terms of both quantitative and qualitative data as proposed by the POM and thereafter to use this model to evaluate the effect of playing educational games. A secondary objective was to assess the applicability of the use of such technology (education games) with learners from a variety of backgrounds (university and senior school students from urban and rural areas).

4.3. CONCLUSION

The chapter discussed technological initiatives, such as educational games, which can be employed in schools to improve learning and teaching. The chapter also introduced ideas that well designed educational games could provide tools to develop cognition and other skills. The next chapter describes the methodologies used in the study which is followed by a chapter detailing the development and evaluation of the research instrument based on POM. The last two chapters report on the evaluation of use of games designed using GOM to investigate the use of such tools with learners from different backgrounds.

CHAPTER 5
RESEARCH METHODS

5.0. INTRODUCTION

The traditional view of *research* is to discover knowledge and *development,* and to translate that knowledge into a useful form in practice (Richey, 1997). In the 1990s, the field of instructional technology experienced debates about the need for a new research paradigm which would add more value to learning. Such debates were a continuation of ongoing debates, about what research in instructional technology should be like with 'traditional' types of research inadequately addressing educational problems, particularly in information and communication technologies (Reeves, 2000). Thus, there emerged, due to persisting problems in the field of instructional technology research, signs of a new paradigm. This chapter will explore the philosophical approaches to research and make explicit approaches used in this study.

The primary objective of this study was to determine the educational value of games designed using the GOM with learners from a wide range of backgrounds. In order to realise this objective it was necessary to first design a research instrument that could be used to describe learners in terms of both quantitative and qualitative data as proposed by the POM and thereafter to use this model to evaluate the effect of playing educational games. A secondary objective was to assess the applicability of the use of such technology (education games like *Zadarh* and *yKhozi*) with learners from a variety of backgrounds (university and senior school students from urban and rural areas).

5.1. PROBLEMS WITH TRADITIONAL RESEARCH

In motivating a move from the traditional research to development research Reeves (2000) argues that research in education should not be carried out for the sake of research but should have practical benefits, and should move from the notion that science is what experts do and practitioners must accept and apply. Reeves, consequently, identified three main problems with the 'traditional' research including: (a) Basic versus applied research, (b) Poor quality of educational research and (c) Disappointing research synthesis. Reeves (1995) asserts that most research studies are:

> "…riddled with problems such as specification error, lack of linkage to theoretical foundations, inadequate literature reviews, poor treatment implementation, major measurement flaws, inconsequential learning outcomes from research participants, inadequate samples sizes, inaccurate statistical analyses, and meaningless discussions of results".

Reeves (1995) argues that the only criterion for success of this research is that papers are accepted for presentation at conferences largely attended by other researchers and/or published in academic journals.

Reeves *et al.* (2003) argue that research in the use of educational technology should be applied and be based on an appropriate developmental research methodology. Such an approach would overcome the problems associated with the use of empirical research methodologies and argue that that such research would result is more appropriate finding that could lead to greater insights into the use of technology in the classroom.

5.2. DEVELOPMENT RESEARCH

"The influence of traditional empirical approaches to educational research on practice is based upon the optimistic assumption that practitioners can or will apply the theories derived from empirical investigations" (Reeves, 2000). Reeves contends that if theories stemming from traditional empirical research have any merit, "the persistence of significant problems in education and training suggest that this optimism is misplaced and that practitioners must be more directly engaged in the conduct of education research". It is because of this problem that other forms of research were proposed. For example, there is a suggestion for research paradigm proposing 'use-inspired basic research' or 'formative research' (Newman, 1990), 'design experiments' (Brown, 1992; Collins, 1992), or 'development research' (van den Akker, 1999). In this dissertation, therefore, the preferred terminology will be 'development research'. Reeves (2000) contends that development research calls for a "pragmatic epistemology that regards learning theory as being collaboratively shaped by researchers and practitioners" with the overall goal of solving real problems while simultaneously constructing "design principles which can inform future decisions". Therefore, a fundamental tenet of development research is collaboration among practitioners, researchers, and technologists and it is not based on a notion of one blanket fits all model where all future research must fit.

5.2.1. Development Research Methods

Methods of development research are not necessarily different from those in other research approaches. However, according to van den Akker (1999), two specific features should be considered: (1) The role of formative evaluation procedures in formative research; and (2) Methodological problems and dilemmas for development researchers. The two features as described by van den Akker are the role of formative evaluation, and problems and dilemmas in development research.

5.2.1.1. The role of formative evaluation

"Formative evaluation is most useful when fully integrated in a cycle of analysis, design, evaluation, revision, etc, and when contributing to improvement of the intervention" (van den Akker, 1999). This author characterises such formative evaluation to include: (a) A priority on information richness and efficiency where the evaluation should both identify shortcomings but also provide solutions, and (b) A shifting of the emphasis in quality from validity to practicality and to effectiveness (Nieveen, 1997).

5.2.1.2. Problems and dilemmas in development research

Van den Akker (1999) explains some of the problems and dilemmas faced by researchers engaging in development research including: (a) Tension in role division between development (designer) and research (researchers); (b) Isolating 'critical' variables versus comprehensive and complex design (many interrelated elements); and (c) Generalisation of findings due to small sample size.

5.2.2. Reasons for Engaging in Development Research

According to van den Akker (1999) there are varying reasons for carrying out development research and these are: (i) The experience that 'traditional' research approaches such as experiments, surveys, etc, "with their focus on descriptive knowledge, hardly provide prescriptions with useful solutions for a variety of design and development problems in education"; (ii) A need for "a growing body of knowledge of theoretically underpinned and empirically tested design principles and methods"; (iii) Reform policies in education that are "often multi-layered and comprehensive" in terms of factors included and people involved; and (iv) Educational research has in general a reputation of lacking relevance from policy makers, practitioners and many researchers who strive for research that contributes to enhancing educational processes with a noticeable impact.

Therefore, one could argue that the development research paradigm fits well with the constructivism paradigm as they are both non-prescriptive in their approach to learning and allow learning to be approached from many differing angles. Just as much as learners come to school with diverse skills and experience even in development research, researchers come from different environments, have different outlooks on life, and have different expectations of research. Thus, their research approaches are going to differ.

5.3. DIFFERENT RESEARCH GOALS

Reeves (2000) identified six common research goals including *Theoretical* (logical analysis and synthesis of theories and or principles), *Empirical* (how education works) *Interpretivist* (interpreting phenomena related to teaching and learning), *Post-modern* (to reveal hidden agendas), *Development* (design principles identification for future educational developments) and *Action* (describe, improve and evaluate effectiveness).

5.4. DEVELOPMENT RESEARCH GOALS

Below is an illustration by Reeves (2000) of the differences between research conducted with traditional empirical goals and that inspired by development goals.

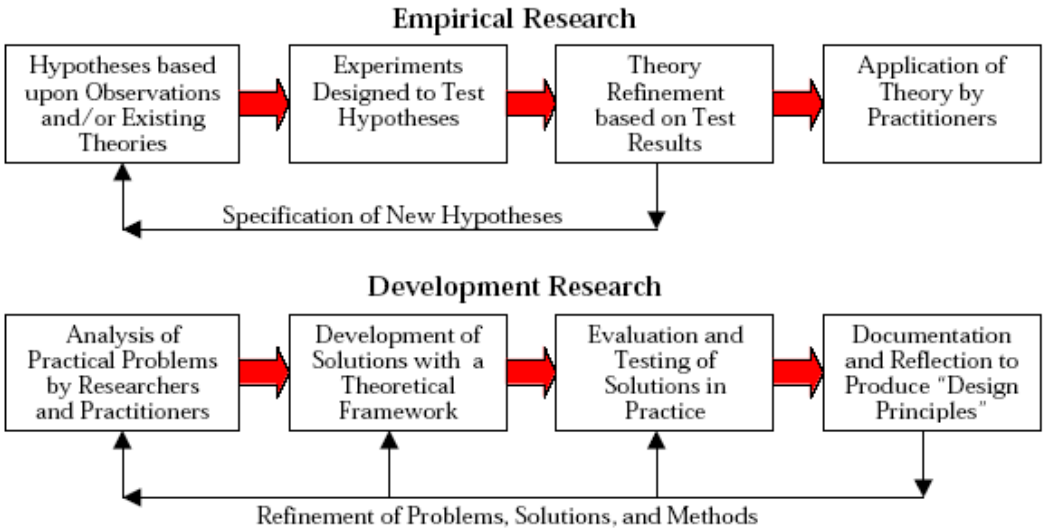

Figure 5.1. Illustrates the differences between empirical research and development research (from Reeves and Hedberg, 2003)

It is seen that empirical research is based on hypothesis based upon observations and or existing theory while the development research is based on analysis of practical problems by both researchers and practitioners (Fig. 5.1).

Reeves and Hedberg (2003) argue that development research: (i) focuses on broad-based, complex problems critical to education, (ii) involves intensive collaboration among researchers and practitioners, (iii) requires long-term engagement that allows for continual refinement of protocols and questions, and (iv) maintains a commitment to theory construction and explanation while solving local problems.

5.5. DOMINANT EVALUATION RESEARCH PARADIGMS

There are differing research methodologies which are currently used in the field of instructional technology. "The status of evaluation within the context of interactive learning is hardly 'well-established' or 'clearly-delineated,' and yet evaluation practitioners are influenced by inquiry paradigms, whether consciously or not" (Reeves and Hedberg, 2003). They based their argument on Kuhn's (1962) contention that the dominant mode of inquiry within a field at any given time depends upon complex interrelationships of theories, measurement assumptions, research methods, and analytical procedures". Therefore, Reeves and Hedberg established the following four dominant research paradigms within the field of instructional technology: Analytic-Empirical-Positivist-Quantitative Paradigm, Constructivist-Hermeneutic-Interpretivist-Qualitative Paradigm, Critical Theory-Neomarxist-Postmodern-Praxis Paradigm and Eclectic-Mixed Methods-Pragmatic Paradigm.

5.5.1. Analytic-Empirical-Positivist-Quantitative Paradigm

According to Reeves and Hedberg (2003) this paradigm **"**represents the most established of the paradigms that guide evaluation in education and the social sciences" and is the most used paradigm in research that is based on the use of quantitative hypothesis testing and includes the use of controls in the design of experiments.

5.5.2. Constructivist-Hermeneutic-Interpretivist-Qualitative Paradigm

Reeves and Hedberg (2003) express that this paradigm is fast gaining in popularity and its proponents have sharply divergent views about the nature of reality from those of the quantitative paradigm. Here it is believed that truth is a collectively constructed reality often through the analyses of text and observations (i.e. qualitative interpretations).

5.5.3. Critical Theory-Neomarxist-Postmodern-Praxis Paradigm

Advocates of this paradigm "wear the label 'social activists' with pride" (Reeves and Hedberg, 2003) and make use of critical theory and deconstruction techniques (post-modernism) that might be of value to educationist.

5.5.4. Eclectic-Mixed Methods-Pragmatic Paradigm

Reeves and Hedberg (2003) argue that this paradigm is the most appropriate approach to handle investigations into the use of technology in the classroom as it allows the use of the many approaches to interrogate a problem from different perspectives that makes 'triangulation' easier. In this paradign 'ecelctic' refers to the use of methods from any of the previously

described paradigms, and 'mixed methods' allow for the use of multiple perspectives whilst 'pragmatic' forster the use of practical approaches to solving research problems.

5.6. EVALUATION MODELS FOR INSTRUCTIONAL TECHNOLOGY

In their recent work (Reeves and Hedberg, 2003) discuss a number of evaluation models including the Tylerian Objectives-Based, Experimental, Patton's Qualitative, Fourth Generation, Post-modern and Multiple Methods Evaluation Models. Reeves and Hedberg (2003) argue that the Multiple Methods Evaluation Model while being complex, also is best aligned with an Eclectic-Mixed Methods-Pragmatic Paradigm.

5.7. DATA COLLECTION STRATEGIES

The methods section describes the overall evaluation design and data collection strategies employed in this study, which are based on the Eclectic-Mixed Methods-Pragmatic Paradigm and use a number of research instruments, including anecdotal records, user questionnaires, user interviews, user focus groups, usability observations and online data collection. These methods support the development research paradigm because of their flexible use, particularly with technology, while allowing future educational developments. The research employed both qualitative and quantitative methodologies. Each represented a fundamentally different inquiry paradigm. Qualitative research uses a naturalistic approach that seeks to understand phenomena in context-specific settings and quantitative research uses experimental methods and quantitative measures to test hypothetical generalizations (Hoepfl, 1997). In order to conduct or evaluate qualitative research, it is important to know the nature of these sometimes hidden assumptions (Myers, 1997). Strauss and Corbin (1990) broadly define qualitative research as, "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification".

5.7.1. Overview of Methods and Analytic Techniques Used

Methods used in this study include case studies, observations, questionnaires, interviews, and paper-and-pencil test as explained below.

5.7.1.1. Case Studies

The case study research method can be defined as an empirical study that uses multiple sources (evidence) to investigate a contemporary phenomenon in a real-world context (Yin, 1984) and emphasise detailed contextual analysis of a limited number of events or conditions and their relationships (Soy, 1997). The weaknesses of case study methods, according to Mikkelson

(1995), are that sometimes they serve as a foundation for generalisations, which might be erroneous. In this study, three schools (Buhlebemfundio, Qhakaza and Tholokuhle) and two universities (University of KwaZulu-Natal and University of Zululand) from the KwaZulu-Natal province formed part of the case study. Learners participated in game play where rich data were collected using direct observations, focus group interviews, questionnaires, examinations of records, and paper-and-pencil tests.

5.7.1.2. Observations

Observation on learners engaging with interactive learning system at various stages of its development can be a valuable, if somewhat humbling experience, and time consuming exercise (Reeves and Hedberg, 2003). Direct observation method is important for collecting information on non-verbal behavioural aspects of people. Here, because some students had no experience with computers, observations were made to determine the ease of learning, the speed of user task performance and subjective user satisfaction (Shneiderman, 1987). Observations also included use of the game environment and interaction between players during game play. Learners from all participating schools were observed to discover the way in which they dealt with the questions, how they reached their conclusions and the way in which they played either *Zadarh* and *yKhozi*. One problem with the direct observation method is that the presence of an observer may affect the behaviour of the participants causing them to alter their normal work behaviour (Giacoppo, 2001). In order to avoid the uneasiness caused by being aware that they were being observed, the researcher gave learners many breaks during which notes from observations were made.

5.7.1.3. Pilot Tests

The purpose of the pilot test instrument is to determine whether the survey instrument is effective for use with the people who are potential respondents, that is, to ascertain if there are any survey items that are confusing, ambiguous, or phrased in language unfamiliar to the intended audience (Thompson and McClintock, 2005). Thus, the purpose of pilot testing is to catch potential problems before they become costly mistakes (EvaluationWiki, 2006). Pilot tests were conducted during the development stages of the study questionnaires in order to iron out discrepancies, be they factual or grammatical, and to provide clarity where necessary. For an instrument testing literacy and communication of learners, two pilot tests were performed. In the first pilot test, Digital Media Masters and Honours students took part and their suggestions were incorporated in the second revised questionnaire. In the second pilot test, only first year UKZN

students participated and their results were included in the final questionnaire used in the study (Annex 1).

5.7.1.4. Questionnaires

Questionnaires are one of the most frequently used methods of collecting effectiveness data and they can be composed of items that address information and attitudes (Reeves and Hedberg, 2003). According to SIECUS (2004) there are drawbacks to using this method as it (i) limits opportunities to probe or provide clarification; (ii) relies on participants' ability to recall behaviour and/or events; (iii) lacks the capability to measure different kinds of outcomes; and (iv) is difficult to use with low-literacy groups. Another weakness of questionnaires is that because of their structured nature they allow little flexibility to the respondent with respect to response format (StatPac Inc., 2000). Also participants might misinterpret questions, and therefore provide wrong information leading to erroneous conclusion (Mikkelson, 1995). The aim of the two sets of questionnaires was to ascertain the real impact of games on learning and to determine the kind of games that could enhance learning skills. In this endeavour, both qualitative and quantitative data were collected. The participating learners from Buhlebemfundo, Qhakaza and Tholokuhle schools and UKZN and UniZulu answered POM questionnaires which covered both qualitative and quantitative data. The qualitative and quantitative data were used to assess the socio-economic status of participants who came from township, urban and semi-urban areas. Quantitative data collected were utilised in measuring participants' literacy and communication skills levels.

5.7.1.5. Focus Groups Interviews

Within the instructional technology field, the focus group method is useful in terms of getting users' reactions to an interface as they use it over time (Reeves *et al*., 2003). However, it has the drawback of only collecting information about what users say they do, and not what they actually do. This can lead to less participation from those intimidated respondents. The method is quicker and cheaper than interviewing the same number of individuals and again a greater pool of expertise is tapped than in individual interviews (Mithcell, 2003. Mikklesen (1995), however, says that focus groups interview methods may have their own problems particularly as participants may be overwhelmed by the responses of their peers or where a few people dominate the discussions. The focus group interview protocol was designed to gather descriptions and details about *γKhozi* and its impact from the interviewees. A small group of Buhlebemfundo learners was brought together and a structured interview with preset questions

was carried out. The focus group interview was intended to evaluate *γKhozi* by ascertaining learners' opinions about it and to find out if they think it is a good teaching tool (Annex 4).

5.7.1.6. Paper-and-pencil

Reeves and Hedberg (2003) say, "Paper-and-pencil tests using multiple choice test items are pervasive as evaluation methods, but the reliability and validity of these instruments are often suspect" and therefore, they caution against the use of tests unless there is evidence of their reliability and effectiveness. SIECUS (2004) raises similar drawbacks to those applying to questionnaires for this method, such as; Limited opportunity to probe or provide clarification; limited question length and breadth; limited capability to measure different kinds of outcomes; and difficult with low-literacy groups. However, according to SIECUS (2004), paper and pencil methods are: Relatively inexpensive and are a quick way of collecting large amounts of data from large samples in short amounts of time; convenient for respondents as they can complete them in their own time; and offer anonymity which can result in more honest responses. The participating learners from Buhlebemfundo, Qhakaza and Tholokuhle schools and UKZN and UniZulu answered paper-and-pencil test that tried to establish their literacy and communication skills levels. Again, learners from Qhakaza and Buhlebemfundo and UniZulu answered a paper-and-pencil test which covered the topics of photosynthesis and respiration. In this study, paper-and-pencil tests were used to collect quantitative data, which were used to determine the level of learners' literacy and communication skills.

5.7.1.7. Student Examination Records

This method interrogates the previous academic records of learners. According to Educator's Guide *(*1998) student records are valuable as such information is easy to obtatin and can be interpreted objectively. However, the other side of this is that these records may not correspond exactly with what the researcher wants; may be incomplete or require additional interpretation; or one may need special permission to use them. Grade 11 examination records for Buhlebemfundo's 2003 and 2004 learners were compared to determine if there was any significant difference between academic skills of the two groups that participated in the research project. This was done to avoid a problem of comparing learners of unequal competences, as this would have compromised the results.

5.7.1.8. Games Play

Playing games is one method used for collecting qualitative and quantitative data. Becta (2004) contends, "A striking feature of games software is its power to motivate". Becta continues to state that it is in provoking and harnessing emotions such as satisfaction, desire, anger, absorption, interest, excitement, enjoyment, and pride in achievement, within the player and their consequences that games software might benefit education. The drawback to games according to Becta (2004) is that they are not universally well designed and many are gender oriented. It is the goal of this research to ascertain if playing *Zadarh* and *yKhozi* will provide learners with the motivation to play and improve their literacy and communication skills whilst learning subjects covered by the game.

5.8. CONCLUSIONS

This chapter explored the philosophical approaches to research and explained explicitly the different approaches used in the study. Great caution and patience were taken in explaining the different research methods and evaluation techniques. Certain specific methods used in the study and their weaknesses were discussed. The next chapter investigates the effectiveness and benefits of using games in enhancing literacy and communication skills of learners.

CHAPTER 6
EVALUATION AND USE OF AN ASSESSMENT TOOL TO MEASURE PLAYER SKILLS

6.0. INTRODUCTION

It is widely accepted that the high failure rates at South African universities illustrates that the curriculum at high school level does not properly prepare students to cope with tertiary level scholarship (Miller *et al.,* 1998). Many reasons are attributed to this state of affairs including, the reliance on the dominant "authoritarian and rote-learning styles of the Apartheid years" (Dean, 2000). This has, however, been overtaken by the new outcome based education introduced under the new 'Curriculum 2005'. In this study, the effectiveness of the two games developed by Virtual Learning Space Project of the University of KwaZulu-Natal will be investigated through the usage of development research methods. The overall goal of development research is to design an interactive learning system that can be used in and outside the classroom, and in real-time or asynchronously as a tool for solving the academic development problems of underpreparedness prevalent amongst majority of South African learners, particularly those who come from the disadvantaged schools.

6.1. ANALYSIS OF PROBLEM

Amory (2001) asserts that games are important in the development of cognitive, literacy, communication, memory, and motor skills. However, little research exists on the evaluation of the educational benefit of games in the classroom and thus, a systematic approach is required. Newman and Lamming (1995) propose the use of a fictitious user, or persona, in the development of software. However, Amory and Seagram (2003) argue that persona data are not built from real data (both quantitative and qualitative) and can, therefore, not be subjected to vigorous evaluations. To overcome this shortcoming these authors propose the Persona Outlining Model (POM) (Fig. 6.1) which consists of a number of spaces described in terms of two interfaces - the abstract (cognitive skills) and concrete [(1) literary – visual, logic, mathematical, computer; (2) communication – reading, writing, speaking; (3) Memory and (4) motor – manipulation, reflexes]. Amory (2001) argues that the use of authentic problems associated with literacy, communication, memory and motor skills (Problem Space of the Game Object Model) could provide a concrete mechanism to address abstract learning goals such as critical thinking, discovery, goal formation, goal completion, competition and practice. Therefore, the following section gives an overview of Persona Outlining Model whereby literacy, communication and memory skills may be evaluated after game playing to determine if the skills levels of participants have improved.

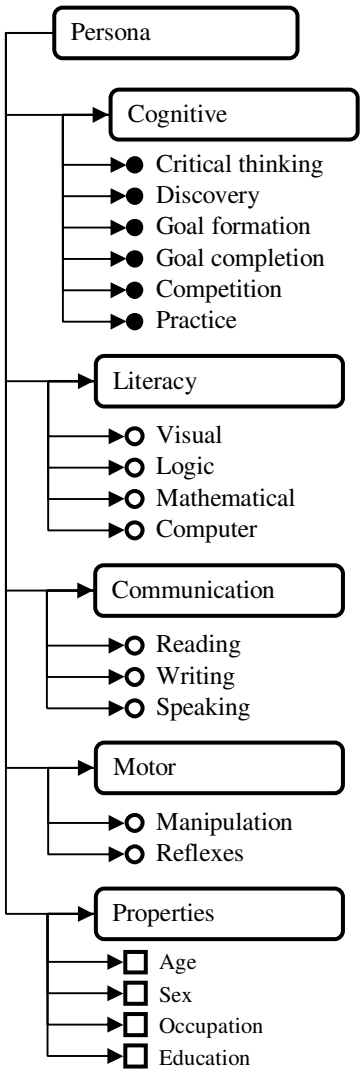

Figure 6.1. Persona Outlining Model

6.1.1. Literacy Skills

The phrases 'ours is not a reading culture' and 'African Society is an oral society' are often used in discussions of literacy, publishing, education levels, book publishing and bookselling and of availability of reading material in Africa (Mulindwa, 2001). However, since the day the print press came into existence the notion of literacy has continued to change especially in the last 100 years (Wiley, 1994). Wiley further states that literacy is a topic of much concern with the media, periodically calling attention to what appears to be a literacy crisis of alarming proportions, claiming that large segments of the adult population is illiterate or very nearly so. De Castell and Luke (1986) identify three distinct paradigms of school-based literacy in recent U.S. history, each highly dependent on the social, economic, and cultural norms of a particular epoch. The first paradigm is represented by the 19th century classical period where literacy was

viewed as knowledge of literature and attention to rhetorical appropriateness. Literacy pedagogy involved rote learning, oral recitation, copying, and imitation of so-called correct speech and writing (Warschauer, 1999). The second paradigm followed the mass industrialisation of the early 20th century and Deweyan progressive paradigm of literacy emerged as a self-conscious attempt to provide the skills, knowledge, and social attitudes required for urbanised commercial and industrial society (de Castell and Luke, 1986). Literacy was viewed as a form of self-expression. Literacy pedagogy involved teacher-pupil interaction and the discovery method. The literacy curriculum included civics, adventure stories, and self-generated texts. The progressive model, however, never fully took hold, rather it was in constant struggle with a more technocratic paradigm that eventually won out (Cuban, 1993). The third was the technocratic paradigm, whereby literacy was viewed as survival skills necessary to function in society. Literacy pedagogy involved programmed instruction, learning packages with teachers as facilitators, and mastery learning of a common set of objectives. The technocratic paradigm that emerged in the 1940s both mimicked and served the needs of the dominant Fordist industrial structure of the era. The technocratic notion of literacy is itself being undermined as further changes in technology and society point to the need for new concepts of literacy (Warschauer (1999). This leads to a new fourth paradigm resulting from the development and spread of Internet technology. This new paradigm is affecting the developments in reading and writing.

In order for literacy assessments to be carried out there has to be an operational definition (Wiley, 1994). There has been considerable debate over how literacy should be defined. Nonetheless, Cashdan (1986) defines it as:

> "Literacy is not simply a matter of decoding print to sounds, or of converting sounds to print. It involves meaning. All of us – children and adults alike – are constantly occupied in making meanings. … Full comprehension means understanding what the writer (or speaker) means by reference to what has not been said as well as what has, by comparison with material, ideas and knowledge outside the immediate text and by analysis of the writer's purposes and of how the message has been coded – its language, style, register or code".

This definition focuses on reading and writing and does not satisfy the modern day society which is more complex. The process of becoming literate today involves more than learning how to use language effectively; rather, the process amplifies and changes both the cognitive and the linguistic functioning of the individual in society (Kasper, 2000). Angelil-Carter (1998) asserts that literacy involves more than simply understanding. It requires an active engagement with problems and the communication of the outcomes of the engagement to an audience. This is in support of Ballard and Clancy (1988) who define literacy as learning to 'read' the culture,

learning to come to terms with its distinctive rituals, values, styles of language and behaviour. Changes in the technologies available for reading and writing have an important impact on how we experience and think of literacy, but technology alone is not all-powerful (Warschauer, 1999). Instead, technological change intersects with other social, economic, cultural, and political factors to help determine how literacy is practiced. Therefore, literacy practices are understood as incorporating all the social practices of a particular group, such as the thinking, interactions, beliefs, and as well as the way it reads and writes.

Angelil-Carter (1998) draws her arguments from literacy theorists who have given weight to the belief that literacy skills are bound up with context specific social practices and that there is a need to understand the acquisition of academic literacies in the context of the varying intellectual and educational practices of individual disciplines. Thus, literacy practices acquired in one context may be less transferable to other fields. School-based literacies may therefore be inadequate preparation for university, and the literacy practices of one discipline in a student's curriculum may be incommensurate with those of another. Therefore, literacy is dependent on the group of people, where becoming fully literate means mastering the 'discourses' of the group. The notion of discourse in this case includes not only the ways of using language but also the beliefs, attitudes and values of the group (Gee, 1990). Therefore, to be considered literate, students today must acquire a battery of skills that will enable them to take advantage of the diverse modes of communication made possible by new technologies and to participate in global learning communities (Kasper, 2000). For purposes of this study, the notion of literacy is defined as development of culturally based skills which are content specific and enable one to actively engage in and be able to draw conclusions from a problematised situation and communicate the outcome. Therefore, literacy is identified as problem-solving skills bound up with context specific social practices.

Therefore, a literate person knows how to gather, analyze, and use information resources to solve problems and make decisions, as well as how to learn both independently and cooperatively (Kasper, 2000). Ultimately, literate individuals possess a range of skills that enable them to participate fully in all aspects of modern society, from the workforce to the family and to the academic community. Kasper goes on to state that succeeding in a digital, information-oriented society demands multi-literacies, that is, competence in an even more diverse set of functional, academic, critical, and electronic skills. Indeed, the development of literacy is a dynamic and ongoing process of perpetual transformation (Neilsen, 1989), whose evolution is influenced by a person's interests, cultures, and experiences.

6.1.1.1. Visual literacy

Visual literacy is an emerging area of study that deals with what could be seen (both physical and mental images) and its interpretations (Pennings, 2002). It is approached from a range of disciplines that: (i) Study the physical processes involved in visual perception; (ii) Use technology to represent visual imagery, and; (iii) Develop intellectual strategies to interpret and understand what is seen. Savander-Ranne (2003) asserts:

> "This intensifies and clarifies the learning process. Using visualisation aids in elucidating abstractions helps students to form mental visual images and make visual interpretations of what concepts mean. Combining visualisation with peer interaction and cooperative learning yields good synergy".

According to Moline (1996) when children begin to read and write they are as interested in information as they are in fiction. But information is not conveyed only with print; the wealth of visual texts are often the clearest communicators of information. Charts, diagrams, cross sections, and maps are a few of the elements that are as critical as the words they supplement. In many cases, the visual text is the clearest way to present information. Based on the idea that visual images are a language, visual literacy can be defined as the ability to understand and produce visual messages (Arizona State University, 1998). The fundamentals of all visual communication are its basic elements; the compositional source for all kinds of visual materials, messages, objects and experiences (Pinkel, 1998). Work in the field has centred on development of educational programs that train learners to evaluate and create visual messages, as well as improvement of reading and writing skills by using visual literacy techniques. Hence, an assumption that people with high visualisation proficiency find it easier to understand and communicate information to others.

6.1.1.2. Logic literacy

"Logical thinking is the ability to make deductions that lead rationally to a certain conclusion. Good logical skills help one to think things through and provide one with understanding the cause and effect relationships (Kerber and Sorge, 2004). Thus, logic deals with what follows from what. Logical thinking is the process in which one uses reasoning consistently to reach a conclusion. Kerber and Sorge opine that logic is the systematic study of the fundamental principles that underlie correct, 'necessary' pieces of reasoning as these occur in proofs, arguments, inferences, and deductions. In this instance the correctness of a piece of reasoning does not depend on what the reason is about so much as on how the reasoning is done; on the pattern of relationships between the various constituent ideas rather than the actual ideas themselves. For this reasoning, logic must abstract its form from its content. Therefore, a logical

skill is the process which involves inquiring about relationships between facts in order to come to a reasoned conclusion.

6.1.1.3. Mathematics literacy

Mathematics literacy, also referred to as "numeracy," is defined as the ability and skills required to understand and use numbers as a means of communication (ABC Canada, 2002). The president of ABC Canada, Christine Featherstone, explains that functional literacy in mathematics means acquiring skills one needs for everyday activities. According to the International Adult Literacy Survey (IALS), approximately 43% of Canadians are at a basic or low numeracy level. This means that close to half of that countries' population do not have functional mathematical literacy. ABC Canada and Ohio Mathematical Planning Committee said for people to be functional in mathematics, they must have the following skills: (i) Mental arithmetic – which requires one to be able to calculate mentally in everyday situations, (ii) General arithmetic requires ability to deal with decimals, fractions, percentages, proportion and the ability to make judgements about estimation and size; (iii) Practical applications of measurement – ensures that students can interpret, use, apply and convert measures appropriately e.g. distance (metres, kilometres, miles etc), temperature, weight, currency (e.g. Rand to Euro) etc.; (iv) Basic algebra – requires a need to use and apply basic formulae, e.g. in relation to capitation, budgets etc; and (v) Handling and using statistical information – requires the ability to use and interpret graphs (including box and whisker diagrams) when target setting or analysing bench marking data. Therefore, literacy in mathematics has been explained to imply:

> "… a solid grasp of quantitative reasoning and appreciation of mathematical applications. Most important is acquisition of knowledge necessary for informed judgment on the uses of mathematical, computational and statistical interpretations confronting us in modern everyday life" (University of Alaska Fairbanks, 2002).

From these discussions, one can deduce that mathematical intelligence is a strong indicator of general intelligence because many every day mental tasks require arithmetical operations even though numbers may not be involved.

6.1.1.4. Computer literacy

In today's ICT driven society it is argued that reading, writing, arithmetic, and discipline specific knowledge is still essential, but no longer sufficient. To be successful, individuals must also be able to search, access, retrieve, organise, interpret and communicate information on-line

(Hirumi, 1995). Valenza (1998) says that in today's information age people confuse computer literacy with information literacy. Computer literacies are fundamental skills students need to leave high schools equipped with in order to face tertiary studies with optimism and confidence. However, students who enter tertiary institutions lacking in these skills will need to acquire them through their normal coursework. Modesto City Schools (2001) lists the following skills as pertinent to computer literacy: (a) Ability to use an operating system which entail: (i) Using and handling of floppy disk; (ii) Formatting and naming of floppy disks; (iii) Using hard disks; (iv) Switching between open applications; (v) Creating folders/directories (file manager/windows explorer); (vi) Deleting unwanted files; (vii) Renaming of files; (viii) Copying or moving files between drives and folders; (ix) Launching applications; (x) Finding and opening files from Windows; and (xi) Using the help menu or contents and index; (b) Word processing; (c) Connecting to the WWW; (d) Conducting searches on the Internet using search engines; (e) Sending and receiving emails; and (f) Downloading and uploading attachments.

6.1.2. Communication Skills

Another set of skills important to acquire for playing educational games is communication. According to SUNY Empire State College (2002) communication involves various skills such as reading, thinking, and writing, or listening, speaking, and observing, all of which can overlap and occur simultaneously as transfer of information takes place. Florez (1999) asserts that communicative and whole language instructional approaches promote integration of speaking, listening, reading, and writing in ways that reflect natural language use. Opportunities for speaking and listening require structure and planning if they are to support language development.

The University of Alaska makes a distinction between functional and advanced literacy and states that functional literacy is not a goal of university education. Regardless of the skill levels in English and mathematics students bring to the university, they must experience an educational process that pushes them beyond the functional to advanced levels. University of Alaska (2002) explains that advanced literacy in communication is a multi-dimensional competence in the use of English, including: (i) The critical comprehension of complex reading material; (ii) The preparation of clear, organized and soundly reasoned statements in a variety of oral and written forms; and (iii) The capability and confidence to participate orally and orally in public forums. Communication skills such as: (a) writing, (b) reading, (c) speaking, and (d) listening are discussed below.

6.1.2.1. Writing Skills

Writing tasks are designed to measure students' skills to clearly communicate ideas and information (Frontenac S.S. Literacy Updates, 2002). Students must demonstrate skills in (i) Developing ideas; (ii) Providing supporting ideas; (iii) Organising and linking information and ideas; (iv) Using appropriate tone; (v) Using correct grammar and punctuation; and (vi) Using correct spelling. Writing summary, series of paragraphs explaining an opinion, news reports, and locating information from within paragraphs are examples of writing tests. Therefore, the ability to communicate ideas clearly and concisely in writing is a key skill for success in every day life, particularly in education and in other professional settings.

6.1.2.2. Reading Skills

According to the Progress in International Reading Literacy Study (PIRLS), a leading international organisation in the field, reading literacy is one of the most important abilities students acquire as they progress through their early school years. “It is the foundation for learning across all subjects, it can be used for recreation and for personal growth, and it equips young children with the ability to participate fully in their communities and the larger society” (PIRLS). The Lynch School of Education, Boston College (2003) gives two purposes for reading as: (i) Reading for literary experience: the reader engages with the text to become involved in imagined events, settings, actions, consequences, characters, atmosphere, feelings, and ideas, and to enjoy language itself. An example of literary reading is narrative fiction. (ii) Reading to acquire and use information: the reader engages with aspects of the real universe to understand how the world is, how it has been, and why things work as they do. One can go beyond the acquisition of information by use it in reasoning and in action. Typical information texts include biographies, accounts of events, procedural texts, persuasive texts, and diagrams, charts and graphs.

6.1.2.3. Speaking Skills

Guerrero and Del Vecchio (1995) opined that communication is the ability to use oral language appropriately and effectively in learning activities, such as peer tutoring - collaborative learning activities, and question/answer sessions - within the classroom and in social interactions within the school. Inside the classroom, speaking and listening are the most often used skills (Brown, 1994). These skills are recognized as critical for functioning in an English language context by both teachers and by learners. Brown goes on to state that Speaking is an interactive process of

constructing meaning that involves producing, receiving and processing information that has its own skills, structures, and conventions different from written language. In support it is asserted:

> "Its form and meaning are dependent on the context in which it occurs, including the participants themselves, their collective experiences, the physical environment, and the purposes for speaking. It is often spontaneous, open-ended, and evolving. However, speech is not always unpredictable. Speaking requires that learners not only know how to produce specific points of language such as grammar, pronunciation, or vocabulary ("linguistic competence"), but also that they understand when, why, and in what ways to produce language ("sociolinguistic competence")" (Florez, 1999).

Therefore, to be proficient in speaking one must be able to integrate this array of skills, both linguistic and sociolinguistic competence, and knowledge.

6.1.2.4. Listening Skills

Another important aspect of communication is to develop good listening skills. Duzer (1997) comments, "Listening is a critical element in the competent language performance of adult second language learners, whether they are communicating at school, at work, or in the community". Listening skills are as vital in our daily lives as they are in learning and teaching. "Outside the classroom, listening is used twice as often as speaking, which in turn is used twice as much as reading and writing" (Rivers, 1981). According to Richards (1983) listening is very much an active process of selecting and interpreting information from auditory and visual clues. Yet listening remains one of the least understood processes in language learning despite the recognition of the critical role it plays both in communication and in language acquisition (Morley, 1991). Listening to learn has become an important element in the adult English as a second language (ESL) classroom (Lund, 1990). In the South African context where the majority of students are second language speakers of English this is even more important. Therefore, listening is an essential aspect of learning.

6.1.3. Memory

In playing games memory is vital. Memory is retention of information over a period of time (Intelegen Inc, 2003). Intelegen Inc illustrates that memory cannot be measured directly but instead must be inferred, based on the behaviour of the organism. The way in which memory is measured is crucial to the interpretation of the results (Messer, 2000). Messers states that several types of memory have been described and have often been divided into two basic types. According to Messers these are declarative and procedural memory where declarative is for facts or events while procedural memory is for skills or behaviours. Declarative memories can be called-up or verbalized and procedural memories are generally nonverbal. Declarative

memories are quite easily learned and forgotten and procedural memories require longer times to learn. “Procedural memories, such as riding a bicycle, are also easier to retain once learned” (Messer, 2000). Declarative memory, that is, memory for facts and events, is rather flexible. For example, facts are learned, utilised, and immediately discarded. We may, however, learn facts and retain information for very long periods. According to Intelegen Inc (2003) there are three basic questions to ask about memory: (i) How are memories formed? (encoding) (ii) How are memories retained? (storage) and (iii) How are memories recalled? (retrieval).

6.1.3.1. Memory Encoding

According to Intelegen Inc (2003) encoding is an active process which requires selective attention to the material to be encoded. Memories may then be affected by the amount or type of attention devoted to the task of encoding the material and there may be different levels of processing which occur and that some are deeper than others. For example, different types of encoding includes: (i) structural encoding which places emphasis on the physical structural characteristics of the stimulus operating at a shallow level, (ii) phonemic encoding which puts emphasis on the sounds of the words is an intermediate level, while (iii) semantic encoding with its emphasis on the meaning is considered deep processing.

In order to enhance the capacity of memory other aspects of encoding are considered. For example, elaboration, visual imagery and self-referent have an important role in encoding. Elaboration is associating with other information, visual imagery can be used to add richness to the material to be remembered, and self-referent makes the material personally relevant and this requires deciding how the information is personally relevant.

6.1.3.2. Memory Retention

According to Intelegen Inc (2003) current theories use a computer based model or information processing model to explain memory. The most accepted model states that there are three stages of memory storage: sensory store, short-term store, and long-term store. (i) Sensory store retains the sensory image for only a small part of a second, just long enough to develop a perception. (ii) Short term memory (STM) lasts for about 20 to 30 seconds without rehearsal of the information, and with rehearsal STM will last as long as rehearsal continues. Again, STM is limited in terms of the number of items it can hold (Miller, 1956) where the capacity is about 7 items and capacity can increase by "chunking" (combine similar material into units). Originally short-term memory was perceived as a simple rehearsal buffer but it turns out to be more complicated. It is not limited to phonemic encoding, and loss of information occurs by other

means than simply decay and displacement, etc. Short-term memory encodes information that is stored for short periods of time and later forgotten (Messer, 2000). (iii) Long-term memory has been suggested to be permanent which means that nothing is forgotten only the means of retrieving it is lost. Long-term memory encodes and consolidates the information for retention over longer time periods (Messer, 2000). Messer further states that this is illustrated by the existence of flashbulb memories such as the vivid recollections of important events such as the death of JFK or the Challenger Space shuttle crash.

6.1.3.3. Memory Retrieval

Memory retrieval is not a random process as it uses cues to help with retrieval. These can be context cues, and mood where recall can occur when the same emotional state is created as was present in the acquisition phase (Intelegen Inc, 2003). Intelegen Inc contends that perhaps some of the errors in recall are a result of failure in source monitoring, that is, remembering the origins of the memories.

6.2. DEVELOPING A SOLUTION

The aim of the research reported in this chapter is to use the concrete interfaces of POM to design, test and evaluate an instrument to define a typical young South African (the persona) in terms of literacy and communication skills which will allow the description of typical game players using indicator scores for the different skills. Components of POM define a typical player in terms of a theoretical model that supports educational game design, are used to develop an instrument to evaluate literacy (visual, logic and mathematics) and communication (reading and writing) skills.

6.2.1. Participating Schools

In this study five institutions participated, three schools namely Buhlebemfundo, Qhakaza, and Tholokuhle and two universities of Zululand [UniZulu] and KwaZulu-Natal [UKZN]. There were 55 participating students from Buhlebemfundo, 26 from Qhakaza, and 51 from Tholokuhle and were all matric students (Grade 12). There were also 27 students from UKZN, first year computer science, and 30 from UniZulu, first year Business Information Systems. The tests were carried out between March and May 2003.

The samples were specifically chosen because the participants represented the demographic and the dynamics of the South African educational landscape. The three high schools represented the community schools for Blacks, which by their very nature are less privileged than those of

their white counterparts. These schools, in comparison again to those of their white counterparts, do not generally produce good results for admission to universities because of poorly trained teachers and lack of other resources like finance. While the universities represent the dynamics of the society and to a large extend still represent the old apartheid era institutions. For example, the UKZN is more financially well-off and better resources than its counterpart UniZulu. Because of its higher admission criteria UKZN, unlike UniZulu admits most Whites and Blacks from privileged backgrounds.

6.2.2. Materials and Tools

The design and development of the instrument to evaluate literacy and communication skills is a compilation of many international tests which were altered to suit the South African environment. The visualisation skills test, taken from Osodo's (1999) masters' degree dissertation, is based on standard test used by the HSRC to determine 2D and 3D special visualisation skills. The logic and numeracy part is similar in nature to the IQ tests given years ago to primary school pupils in the USA by an organisation called 'Pressanykey' in an effort to gauge their learning skills. The communication skills tests used the modified American Student Aptitude Test (SAT) and a short passage from African Proverbs, Stories and Sayings - African Stories (http://www.afriprov.org/resources/stories.htm). The tests are used to gauge the literacy and communication skills, which South African learners bring to tertiary institutions. These skills, as previously mentioned, are significant as they enable those learners who are proficient in them to cope better with their university studies.

The instrument is divided into two sections with the first asking participants to provide some biographical information but did not include any identification information. The second part forms the core of the research instrument which tested the literacy and communication skills of learners. Two pilot study investigations were conducted to identify problems associated with the design and implementation of the instrument. The first pilot test was administered to Digital Media Honours and Masters Students (University of KwaZulu-Natal) who answered all questions and were interviewed to gain insight into problems associated with the instrument. The results from this investigation were used to modify the instrument used in the second pilot study where UKZN first year learners from different faculties participated. Again, both their answers and opinions were included in the final instrument later administered to the five schools (Buhlebemfundo, Qhakaza, Tholokuhle, UKZN and UniZulu).

6.3. EVALUATION AND TESTING OF SOLUTION IN PRACTICE

6.3.1. Results on Visualisation Skills

6.3.1.1. 2D Visualisation Skills

Nine questions (Fig. 6.2) were used to determine the 2D visualisation skills of learners who were requested to identify two objects made up of the same components but arranged differently. Learners had to visualise the way an object would look like after being rearranged before making their choices. The overall performance for this section was poor with the mean of 41.9% and only UKZN learners with 69.5% scored above 50%. Participants from Qhakaza scored 41.1%, Tholokuhle 37.9%, Buhlebemfundo 34.2% and UniZulu 32.2%.

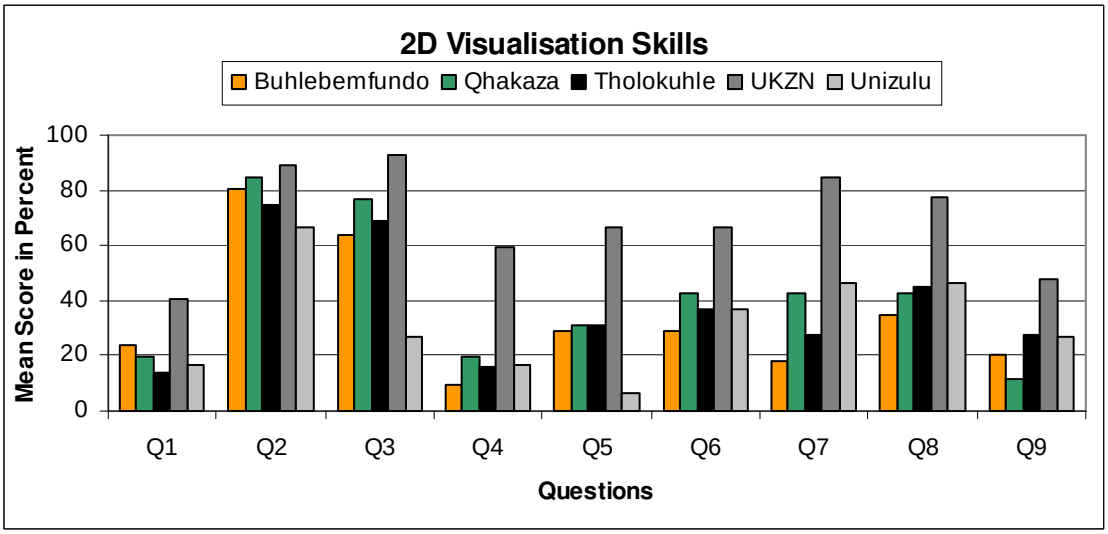

Figure 6.2. Results for the 2D Visualisation Skills questions represented as a percentage

Learners performed well on the two questions which asked about rearranged rectangles. For example, a high number (79%) of learners chose the correct answer (c) and were able to transpose rectangular shapes for question 2. Buhlebemfundo averaged 80.1%, Qhakaza 84.7%, Tholokuhle 74.5%, UKZN 88.8%, and UniZulu 66.6%. For question 3, which combines rectangles and arcs, 65% of learners chose the correct answer (e) with Buhlebemfundo averaging 63.7%, Qhakaza 77%, Tholokuhle 68.6%, UKZN 92.5% and UniZulu 26.6%.

Performance was poor on questions which involved arcs and circles. For question 1 only 22.8% of all participants got the correct answer (e) with Buhlebemfundo averaging 23.7%, Qhakaza 19.3%, Tholokuhle 13.8%, UniZulu 16.7% and UKZN the highest with 40.7%. On the other hand 36.1% of learners chose the wrong answer (b) with UniZulu having 53.3%, Qhakaza 38.5%, Buhlebemfundo 32.7%, Tholokuhle 37.3% and UKZN 18.5%.

For question 8 only half (49.3%) of all learners gave the correct answer (d). With the exception of those from UKZN who averaged 77.7% no other school had a mean score of more than 50% as Buhlebemfundo had 34.6%, Qhakaza 42.4%, Tholokuhle 45.1% and UniZulu 46.6%. One third (33.8%) of all learners chose (d) the wrong answer. More than half (52.7%) of Buhlebemfundo, Tholokuhle's 41.2%, Qhakaza's 30.8% and UKZN's 11.1% provided wrong answers.

Question 9 was the worst performed with only 26.7% giving the correct answer (c). Qhakaza's mean of 11.6% was the lowest and UKZN was the highest with 48.1%. Buhlebemfundo had 20%, Tholokuhle 27.4%, and UniZulu 26.6%. However, the wrong answer (e) Buhlebemfundo averaged 45.5%, Qhakaza 57.7%, Tholokuhle 45.1% and UKZN 25.9%.

Performance was again poor where triangles were involved, such as in questions 4, 6 and 7. Question 4 with the correct answer (e) and the overall performance at 24% was poor. Buhlebemfundo had the lowest mean of 9.1%, followed by Tholokuhle's 15.7%, UniZulu's 16.7%, Qhakaza 19.3%, and UKZN was the highest with 59.2%. On this question 65.3% of learners, Buhlebemfundo's 81.8%, Qhakaza's 69.2%, Tholokuhle's 64.7%, UniZulu's 70% and UKZN's 40.7% chose the wrong answer (c).

For question 6, only 42.4% chose the right answer (d) with Buhlebemfundo attaining 29.1%, Qhakaza 42.2%, Tholokuhle 37.2%, UniZulu 36.7% and UKZN the highest with 66.6%. However, the wrong answer (c) was chosen by 30.7% of students (Buhlebemfundo 47.3%, UniZulu 36.7%, Qhakaza 30.8%, Tholokuhle 27.5%, and UKZN's 11.1%).

For question 7, the correct answer (c) was picked by 43.9% of learners where Buhlebemfundo was the lowest with 18.2% and UKZN the highest with 85.1%. Qhakaza had 42.4%, Tholokuhle 27.4% and UniZulu 46.6%. Again, two fifth (39.9%) of students wrongly chose (b) led by majority of Buhlebemfundo 65.5% and Tholokuhle 54.9%. Qhakaza and UniZulu had respective 34.6% and 30%.

6.3.1.2. 3D Visualisation Skills

Fourteen questions were used to determine the 3D visualisation skills of learners (Fig. 6.3). These exercises required the matching of similar figures viewed from different angles. The

performance was good with the overall mean of 63.2% where Buhlebemfundo obtained 53.9%, Qhakaza 67%, Tholokuhle 57.2%, UKZN 79.6%, and UniZulu 62.8%.

Unlike with 2D questions, it is evident from the results that learners found working with 3D objects easier than 2D objects. This is seen in questions 10 to 14 where the lowest average was in question 10 with 65.7% and the highest was 87.6% for question 13.

For question 10, most learner were able to select the right answer (d) with UniZulu getting the least mean of 53.3% and UKZN the highest with 77.7%. Buhlebemfundo had the mean of 63.7%, Qhakaza 69.3% and Tholokuhle 64.7%. The overall mean for question 11 was 73.7% with (a) the correct answer. Buhlebemfundo got 67.4%, Qhakaza 65.5%, Tholokuhle 76.5%, UKZN 92.5% and UniZulu 66.6%.

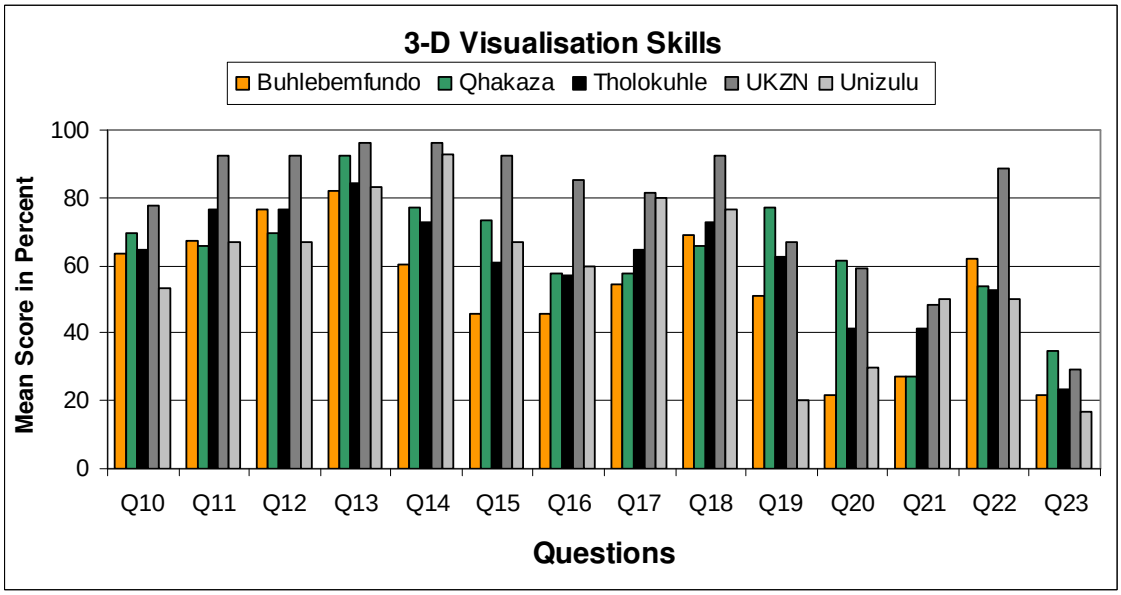

Figure 6.3.Results for the 3D Visualisation Skills questions represented as a percentage

For question 12 with the overall mean of 76.3% the correct answer was (e) and Buhlebemfundo obtained 76.5%, Qhakaza 73.7%, Tholokuhle 76.5% and UniZulu 66.6% and UKZN with 92.5% was the highest. For question 13, the correct answer was (c) and the overall mean was 87.6%. Buhlebemfundo was the lowest with 81.9% and UKZN the highest with 96.2%. Qhakaza's mean was 92.4%, Tholokuhle 84.3% and UniZulu 83.3%. The mean for question 14 mean was 79.8% where the correct answer was (d). Buhlebemfundo had 60.9%, Qhakaza 77%, Tholokuhle 72.6%, UKZN 96.2%, and UniZulu 93.2%.

For questions 15 to 23 learners did not do well on questions which were manifesting in 2D but performed well where 3D was clearly noticeable. For example, mean scores for questions 15 to 18 were high because 3D objects could still be identified in their entirety.

On question 15 the right answer was (c) and the overall mean was 67.7%. UKZN learners had the highest mean scores of 92.5% and Buhlebemfundo the lowest at 45.5%. Qhakaza had 73.2%, Tholokuhle 60.8% and UniZulu 66.6%. About a quarter of Buhlebemfundo (27.3%) chose (b) the incorrect answer. For question 16 the right answer was (b) chosen by 61% from all groups and the lowest was Buhlebemfundo with 45.5%. UKZN learners had the highest mean of 85.1% and Qhakaza had 57.7%, Tholokuhle 56.8% and UniZulu 60%. Buhlebemfundo's 29.4% chose the wrong answer (c).

For question 17 with the overall mean of 67.7% most students were able to give the right answer (d). UKZN and UniZulu averaged 81.4% and 79.9%, respectively. All schools performed well with Tholokuhle at 64.7%, Buhlebemfundo 54.6% and Qhakaza 57.7%. Again, a third (29.1%) of Buhlebemfundo selected (a) the wrong answer. Question 18 also saw a high mean of 75.3% for the correct answer (d) with UKZN's 92.5% the highest. Buhlebemfundo averaged 69.2%, Qhakaza 65.5%, Tholokuhle 72.6%, and UniZulu 76.6%.

The performance was poor on questions 19 to 23 just like in the previous 2D skills test because these questions were manifesting in strong 2D and made their identification difficult for most learners. For question 19, the right answer was (e) and the overall mean for all groups was 55.5% with only UniZulu scoring a poor mark of 20%. Buhlebemfundo averaged 51%, Qhakaza was the highest with 77%, while Tholokuhle and UKZN had 62.7% and 66.6% respectively. However, about a quarter (24.8%) of learners gave the wrong answer (b) (Buhlebemfundo 27.3%, Qhakaza 26.9%, Tholokuhle 23.5%, UKZN 16.7% and UniZulu 24.8%).

For question 20, with the overall mean of 42.8% the correct answer was (d) and Qhakaza with 61.6% and from UKZN 59.2% performed better than Buhlebemfundo with 21.9%, Tholokuhle 41.2%, and UniZulu's 30%. Many learners (27.7%) selected the wrong answer (b) such as Buhlebemfundo with 30.9%, UniZulu 36.7%, Qhakaza 23.1%, and Tholokuhle 29.1%. For question 21, with the overall mean of 38.7%, only UniZulu averaged above 50% by choosing the right answer (c). Buhlebemfundo participants achieved 27.3%, Qhakaza 27%, Tholokuhle 41.2% and UKZN 48.1%. The alternative answer (a) was selected by 21.3% of learners and Buhlebemfundo had 36.4%, Qhakaza 26.9%, and UniZulu 26.7%. Question 23, was passed by only a quarter 25.3% of learners who chose (c) and no school scored above 50% where

Buhlebemfundo averaged 21.9%, Qhakaza 34.7%, Tholokuhle 23.5%, UKZN 29.6% and UniZulu 16.7%. A third (29.6%) of the participants chose the wrong answer (e) with Buhlebemfundo averaging 41.8%, Qhakaza 23.1%, Tholokuhle 35.3%, UKZN 44.4% and UniZulu 3.3%.

Question 22 is the only question showing huge 2D appearance which majority of learners passed with an average of 61.5% by selecting the correct answer (b). UniZulu was the lowest with 50% and UKZN the highest at 61.9%. Buhlebemfundo had 61.9%, Qhakaza 53.9% and Tholokuhle 52.9%. The alternative answer (e) was picked by a fifth (19.3%) of learners, 21.8% of Buhlebemfundo, Tholokuhle's 29.4% and UniZulu's 26.7%.

6.3.1.3. Folding Metal Sheets (2D to 3D Visualization)

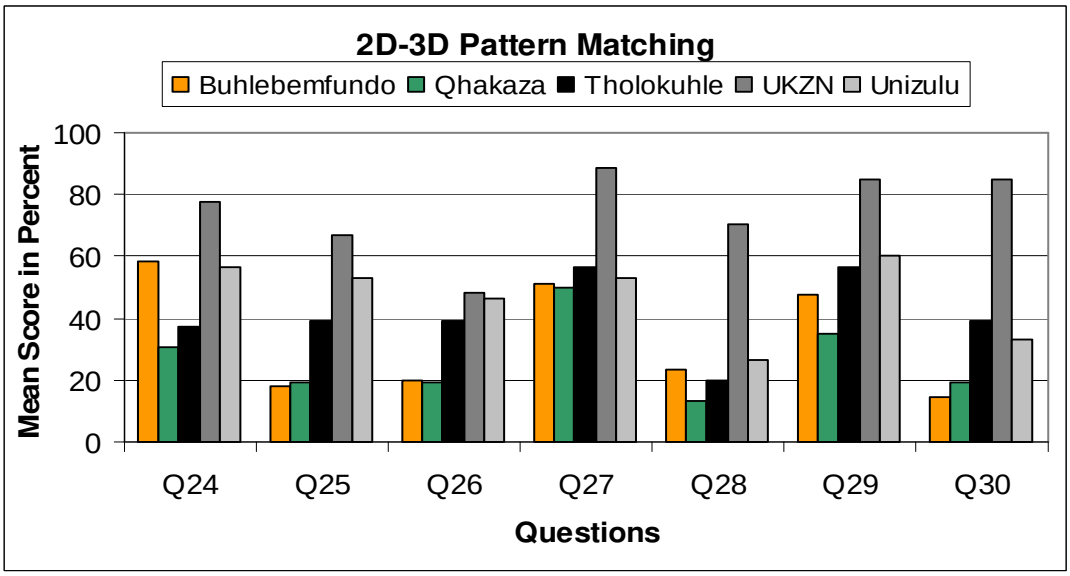

Figure 6.4. Charts illustrating scores on Matching Patterns represented in Percentage

Seven questions were used to evaluate learners' ability to change 2D objects into 3D objects where they had to mentally fold, along the perforated lines, flat objects made from pieces of metal or cardboard (Fig. 6.4**).** With the overall mean of 44.5%, only UKZN with the overall mean of 74.5% scored above 50%. UniZulu averaged 47.1%, Buhlebemfundo 33.3%, Qhakaza 26.7% and Tholokuhle 41.1%. Most learners lacked the mental proficiency to visualise the newly formed 3D objects from the 2D flat sheets.

For question 24 only 52.1% of learners were able to identify the semi-cylinder with closed sides in (b). Buhlebemfundo scored 58.3%, Qhakaza 30.8%, Tholokuhle 37.2%, UniZulu 56.6% and

UKZN the highest with 77.7%. However, 29% of all learners chose the wrong answer (c) Qhakaza leading with 46.2%.

Questions 25 to 28 were also poorly answered. For question 25 only 39.3% of the students chose the correct answer (d) with only the universities learners averaging above 50%, UniZulu 53.3% and UKZN 66.6%. Buhlebemfundo's mean of 18.2% was the lowest, followed by Qhakaza with 19.3% and Tholokuhle's 39.2%. However, more school learners (37.2%) chose the wrong answer (b) than those who selected the write answer (Buhlebemfundo 56.4% and Qhakaza's 57.7%). For question 26 the right answer (b) a three-quarter cylindrical shape was chosen by 34.6% of learners. Only 48.1% of UKZN and UniZulu's 46.6% scored above 40%. Buhlebemfundo had 20%, Qhakaza 19.3% and Tholokuhle 39.2%. Over a quarter of all learners (26.5%) chose the wrong answer (a) even though it was a rectangular shape, that is, almost half (45.5%) of Buhlebemfundo and about a third (30.8%) of Qhakaza.

For question 27 only 60% of learners chose the right answer (a) and UKZN was the highest with 88.8% Buhlebemfundo scored 51%, Qhakaza 50%, and UniZulu 53.3%. Only 17.2% of all learners selected the wrong answer (b). For question 28, only 32.3% chose the correct answer (b) and more students (46.5%) picked the wrong answer (c). Buhlebemfundo with 23.7%, Qhakaza 13.3%, Tholokuhle 19.6% and 26.6% of UniZulu had the correct answer. Only UKZN scored over 50% at 70%. Three quarters of Qhakaza (73.1%), about half of Buhlebemfundo (45.5%) and Tholokuhle (49%) had the wrong answer (c).

For question 29, the correct answer (a) was given by 56.8% of learners. Qhakaza with 34.7% and Buhlebemfundo with 47.3% had the lowest scores. Tholokuhle attained 56.8%, UniZulu 60% and UKZN 85.1%. However, 19.4% of all learners, 30.8% of Qhakaza and 23.6% of Buhlebemfundo had chosen the wrong answer (b). Question 30 was another one badly performed with only 85.1% of UKZN choosing the correct answer (c). Buhlebemfundo got 14.6%, Qhakaza 19.3%, Tholokuhle 39.2% and UniZulu 33.3%. On the other hand 28.7% of all learners, (Buhlebemfundo 49.1% and Qhakaza 42.2%) chose the wrong answer (d).

6.3.2. Results on Logical and Numerical Skills

Thirty questions were used to assess the learner's ability to logically discern numerical and logical and to apply them to new contexts. Participants achieved an overall mean of 45.9% with only UKZN averaging above 50% with 70.8%. All other schools averaged less than 50% with Buhlebemfundo at 37.72%, Qhakaza 46.7%, Tholokuhle 36.5% and UniZulu 40%. Most

learners performed well on questions not requiring much thought. This illustrates that most learners had low reasoning skills and are underprepared to study at tertiary schools. (Fig. 6.5)

For question 31 with the overall mean of 70.4% for all students asked, “Which one of the five is least like the other four (a) Bear (b) Snake (c) Cow (d) Dog (e) Tiger” and the correct answer was (b) because the others were four legged animals. Qhakaza had the highest score of 92.4% followed by UKZN with 81.8% and the lowest with 43.1% was Tholokuhle. Buhlebemfundo and UniZulu had 58.3% and 76.6% respectively.

Question 32 needed the word “BARBIT” rearranged in order to form the name of an animal “rabbit” (e). The overall mean was 70.5% and UKZN was highest with 92.5% followed by Qhakaza at 88.6%, Tholokuhle 82.4%, and Buhlebemfundo 69.2% while UniZulu with 20% was the lowest.

Question 33 asked “Which one of the five is least like the other four (a) Potato (b) Corn (c) Apple (d) CARROT (e) Bean”. The correct answer was (c), and the others were vegetables, chosen by 61.3% of all students. Qhakaza and Tholokuhle did well with 84.7% and 70.6% respectively. Buhlebemfundo was below 50% at 49.2% while UKZN and UniZulu had 51.8% and 50%, respectively.

Question 34 asked learners to calculate some basic ratios of the ages of two brothers where, “Salim, twelve years old, is three times as old as his brother. How old will Salim be when he is twice as old as his brother?” Only 31% of all participants chose the correct answer (b) “16”. Buhlebemfundo had 23.7%, Qhakaza 11.6%, Tholokuhle 15.7%, UniZulu 30% and the only school that passed was UKZN with 74%.

Question 35 tried to find the best comparison to “Brother is to sister therefore niece is to? (a) Mother (b) Daughter (c) Aunt (d) Uncle (e) Nephew” and on the overall 54.4% got the correct answer (e) “Nephew”. Brother and sister, and niece and nephew are all opposites. UniZulu was the lowest with 3.3% followed by Buhlebemfundo with 47.3% and Tholokuhle had 66.7%. UKZN and Qhakaza were the highest with 81.4% and 73.2%, respectively.

Questions 36 asked for comparison that if milk is to glass then letter is to what, (a) Stamp (b) Pen (c) Envelope (d) Book (e) Mail. The correct answer (c) was chosen by 65.2% of all learners. Buhlebemfundo learners attained 47.3%, Qhakaza 53.9%, Tholokuhle 52.9%, UKZN 88.8% and UniZulu 83.3%.

Question 37 attempted to find the best comparison to “LIVE is to EVIL as 5232 is to: (a) 2523 (b) 3252 (c) 2325 (d) 3225 (e) 5223”. EVIL is the reverse spelling of LIVE; the reverse of 5232 is 2325, therefore, the correct answer (c) was chosen by 61.7% of all learners. Buhlebemfundo with 49.2% and UniZulu with 46.6% were the lowest. The highest performers were UKZN with 96.2% while Qhakaza had 65.5% and Tholokuhle 51%.

Question 38 compared three items to ascertain if the statement "If some Smaugs are Thors and some Thors are Thrains, then some Smaugs are definitely Thrains" is (a) True, (b) False or (c) Neither. Only 16.9% of all learners had the correct answer with no school getting over 50%. UKZN was the best performer with 29.6 % and Buhlebemfundo had 18.2%, Qhakaza 11.6%, Tholokuhle 11.8%, and UniZulu 13.3%.

Question 39 asked for the best comparison to “Tree is to ground as chimney is to: (a) smoke (b) Brick (c) Sky (d) Garage (e) House”. The correct answer was (e) “House” and only 28.7% of all students were able to compare the two. House is the answer because tree comes up out of the ground, just as a chimney comes up out of a house. Only UKZN passed with 74%. Buhlebemfundo had 29.1%, Qhakaza 23.1%, Tholokuhle 13.8%, and UniZulu 3.3%

Question 40 asked if the letters "MANGERY" are rearranged what would one get (a) Ocean (b) Country (c) State (d) City (e) Animal”. The answer (b) “Germany” was selected by 54% of all learners and UKZN topped the list with 81.4%. Buhlebemfundo had 47.3%, Qhakaza 38.5%, Tholokuhle 52.9% and UniZulu 50%.

Question 41 wanted to find out “Which one of the five is least like the other four? (a) Touch (b) Taste (c) Hear (d) Smile (e) See”. The correct answer was (d) “Smile”, which was not like the rest because the others are senses while smile is a facial expression, was chosen by 55.4% of all learners. Buhlebemfundo had 38.2%, Qhakaza 57.7%, Tholokuhle 35.3%, UniZulu 53.3% and UKZN had the highest mean of 92.5%.

Question 42 tried to determine who was taller than the others between Sipho who is taller than Peter, and Bill is shorter than Sipho. The right answer was (d) which stated that it is impossible to tell who is taller between Bill and Peter without more information and was selected by 67.2% of all learners. UKZN had 74%, Buhlebemfundo 54.6%, Qhakaza 73.2%, Tholokuhle 60.8 %, and UniZulu 73.3%.

Question 43 asked for identification of an item that was different from others (a) stocking (b) dress (c) shoe (d) wallet (e) hat. “Wallet” (d), was the least like the others and was chosen by 61.4% of learners. Buhlebemfundo participants had a mean of 41.9%, Qhakaza 69.3%, Tholokuhle 43.1%, UKZN 92.5% and UniZulu 60%.

Question 44 compared the sequences of numbers to alphabetical letters and coded CACAACAC as 31311313. The overall mean was 73.0%; Buhlebemfundo participants scored 69.2%, Qhakaza 80.1%, Tholokuhle 66.6%, UKZN 96.2% and UniZulu 60%.

Question 45 asked if the letters "RAPIS" are rearranged what name would one get (a) Ocean (b) Country (c) State (d) City (e) Animal”. The answer is (d) “Paris” was selected by 56.5% of all learners and UKZN topped the list with 88.8%. Buhlebemfundo had 36.4%, Qhakaza 53.9%, Tholokuhle 47%, and Unizulu 56.6%.

Question 46 asked whether the statement "If some Bifurs are Bofurs and all Gloins are Bofurs, then some Bifurs are definitely Gloins" is (a) True (b) False or (c) Neither. The correct answer (b) “False” was selected by 24.9% of all learners with Tholokuhle at 23.5% and UKZN 18.5% the lowest. Buhlebemfundo had 25.5%, Qhakaza 27%, and UniZulu 30%.

Question 47 wanted to find the best comparison to “Water is to ice as milk is to: (a) Honey, (b) Cheese (c) Cereal (d) Coffee (e) Cookie”. The right answer (b) “Cheese” meant that “Water changes into ice and milk changes into cheese” was selected by 55.4% of all learners. Buhlebemfundo attained 38.2%, Qhakaza 61.6%, Tholokuhle 39.2%, UKZN 81.4% and UniZulu 56.6%.

Question 48 asked “By what percent must the item be increased to again sell the article at the original price if it was earlier cut by 20%: (a) 15% (b) 20% (c) 25% (d) 30% (e) 40%”. Only 23.3% chose the correct answer (c) “25%”, Buhlebemfundo attained 9.6%, Qhakaza 15.4%, Tholokuhle 13.8%, UniZulu 16.7 and UKZN 37%.

Question 49 tried to ascertain, “Which one of the five is least like the other four? (a) Bottle (b) Cup (c) Tub (d) Funnel (e) Bowl”. With the overall mean score of 37% only UKZN with 70.3% passed. Tthe answer was (d) “funnel” as the others hold liquids while liquids pass through a funnel. Buhlebemfundo got 36.4%, Qhakaza 19.3%, Tholokuhle 15.7%, and UniZulu 43.3%.

Question 50 asked how many cookies did Musa start with if after eating one and giving half the remainder to her sister, she ate another cookie and gave half of what was left to her brother she was left with five (a) 11 (b) 22 (c) 23 (d) 45 (e) 46. Only 27.7% of learners chose correctly and UKZN with 66.6% was the highest. Buhlebemfundo had 20%, Qhakaza11.6 %, Tholokuhle 13.8%, and UniZulu 26.6 %.

Question 51 tried to ascertain the difference between metals and non-metals (a) Copper (b) Iron (c) Brass (d) Tin (e) Lead and 19.7% of all learners gave the correct answers (c) “Brass” which is a combination of two metals while the others are simple metals. Buhlebemfundo was the worst performer with 10.9%, Qhakaza 15.4%, Tholokuhle 23.5% UKZN 18.5%, and UniZulu 30%.

Question 52 asked which one of the five was least like the other four if “Belt is to buckle as shoe is to (a) Sock (b) Toe (c) Foot (d) Lace (e) Sole”. Performance was poor with 30.8% of all participants giving the correct answer (d) “Lace”. Buhlebemfundo scored 18.2%, Qhakaza 7.7%, Tholokuhle 23.5%, UKZN 70.3% and Unizulu 13.3%.

Question 53 asked whether the statement that follows is (a) True (b) False or (c) Neither: "If all Wargs are Twerps and no Twerps are Gollums, then no Gollums are definitely Wargs." “True” (a) was the answer as the assumption can definitely be made. At 35.6% the overall pass was low with Qhakaza achieving the lowest score of 4% followed by Buhlebemfundo with 23.7% and UniZulu 30%. UKZN was the highest with 70.3% and Buhlebemfundo had 50%.

Question 54 asked for comparisons to be made by asking “Which one of the five makes the best comparison” if “Finger is to hand as leaf is to (a) Tree (b) Branch (c) Blossom (d) Twig (e) Bark”. A low 24% selected the right answer (d) “Twig” because leaf is attached to a twig as a finger is attached to a hand. Buhlebemfundo got 10.9%, Qhakaza 7.7%, Tholokuhle 19.6%, UKZN 51.8% and Unizulu 30%.

Question 55 wanted to find out how many trips to the store did John have to make to collect 9 cans of peaches if he could only carry 2 cans at a time (a) 4 (b) 4½ (c) 5 (d) ½ (e) 6. The overall 41.6% of students got the right answer (c) “5” even though for one of the trips John would get one can. Only UKZN learners averaged above 50% with the score of 81.4%. UniZulu averaged 46.6%, Buhlebemfundo 27.3%, Qhakaza 23.1%, and Tholokuhle 29.4%.

Question 56 wanted to find out how many students competed if Zola was 13th highest and 13th lowest in a spelling contest. (a) 13(b) 25 (c) 26 (d) 27 (e) 28. The correct answer (b) “25” was achieved by 13.6% with none of the schools obtaining means above 50%. There are 12 students lower and 12 students higher plus Zola is 25. UKZN was the highest with 44.4% while other schools did not exceed 10% with Buhlebemfundo getting 7.3%, Qhakaza 0%, UniZulu 6.7% and 9.8% attained by Tholokuhle.

Question 57 tried to find out which one of the five was least like the other four? (a) Ham (b) Liver (c) Salmon (d) Pork (e) Beef. The correct answer was (c) “Salmon” is a fish and others were meats and 56.6% of participants got it right. Buhlebemfundo averaged 67.4%, Qhakaza 38.5%, UKZN 77.7%, Tholokuhle 49%, and Unizulu 50%.

Question 58 wanted to find out if the statement “If all Fleeps are Sloops and all Sloops are Loopies, and then all Fleeps are definitely Loopies" is (a) True (b) False or (c) Neither”. The correct answer was (a) “True”. The overall mean was 48.3% with UKZN the highest at 81.4% followed by Qhakaza with 73.2%. Buhlebemfundo with 41%, Tholokuhle 15.7% and UniZulu at 30% were the lowest.

Question 59 deals with measurements and asked which one of the five is least like the other four (a) CM, (b) Kilometre, (c) Acre, (d) Metre, (e) Millimetre. Most learners (85.2%) selected the right answers (c) “acre” which denotes an area, while the rest refer to distance. Buhlebemfundo scored 85.6%, Qhakaza 88.6%, Tholokuhle 78.4%, UKZN 100% and UniZulu 73.3%.

Question 60 tried to discover which three coins Sipho received after a purchase from the supermarket where he was given a change of R0.41 made up of six coins (a) Cents, (b) Five cents, (c) Ten cents, (d) Twenty cents (e) Fifty cents. The correct answer was (c) “Ten cents” because 3 ten cents, 2 five cents, and 1 cent is the only possible solution. The overall mean was 36.2% and with 59.2% of UKZN got above 50%. Buhlebemfundo averaged 31%, Qhakaza 30.8%, Tholokuhle 23.5% and Unizulu 36.6%.

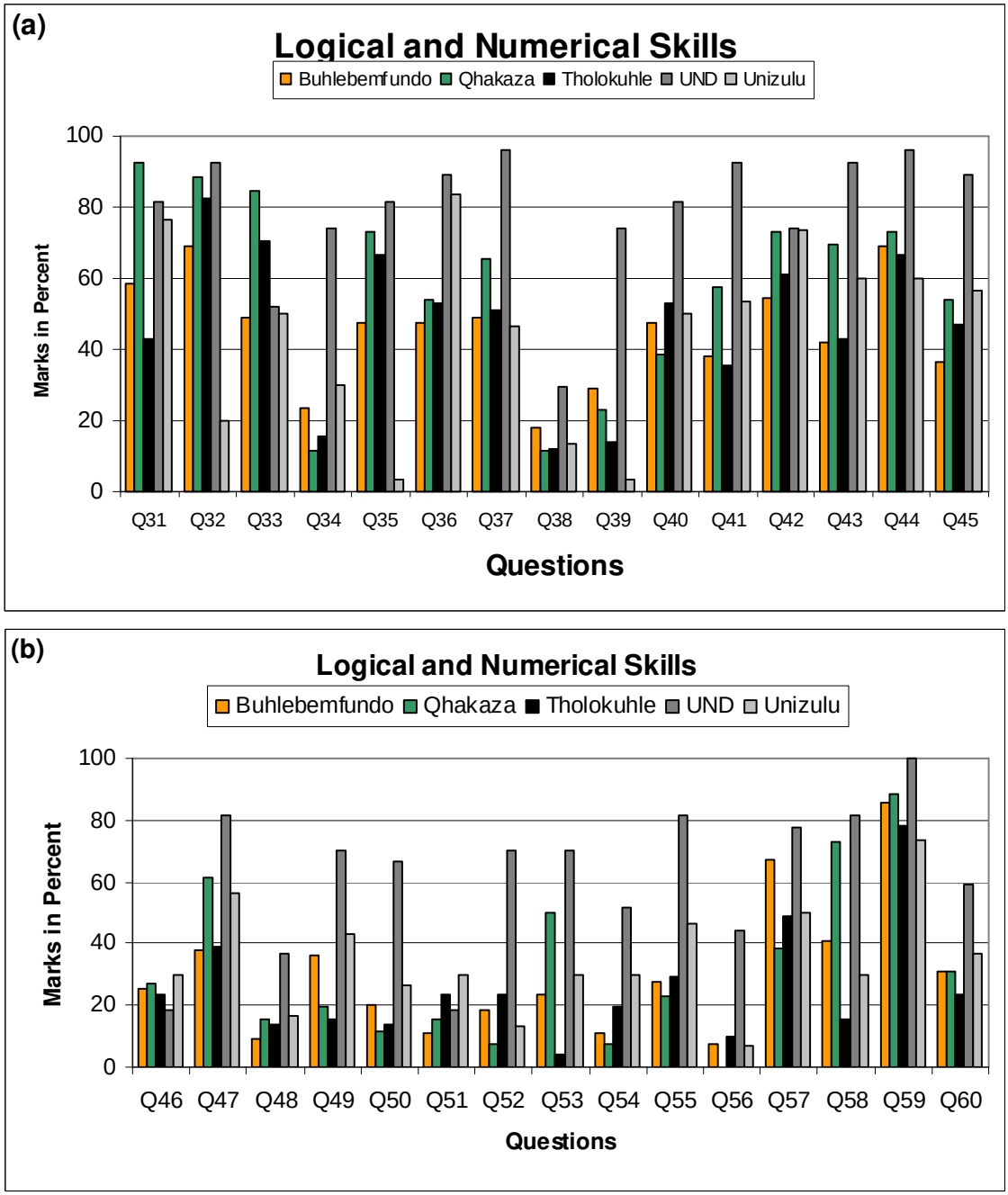

Figure 6.5: Logical and numerical skills results for the 5 schools.

6.3.3. Results on Communication Assessment

The overall communication results indicate that most learners lack these skills. Buhlebemfundo had the lowest score of 33.6 % while UKZN was the highest with 83.1%. The other schools also had low communication skills scores with Qhakaza getting 50%, Tholokuhle 42.2% and UniZulu 51.3%.

6.3.3.1. Structuring Sentences

Questions 61 to 64 of this part of the assessment instrument investigated the ability of students to write well-structured English sentences with the correct tense. Learners had to choose the correct word from the four provided multiple-choice alternatives. The overall mean for the participating schools was 64.6% and Buhlebemfundo averaged 57.1%, Qhakaza 61.8%, Tholokuhle 47.1%. However university students outperformed the school participants with UKZN at 90.7% and 68.3% for UniZulu (Fig. 6.6).

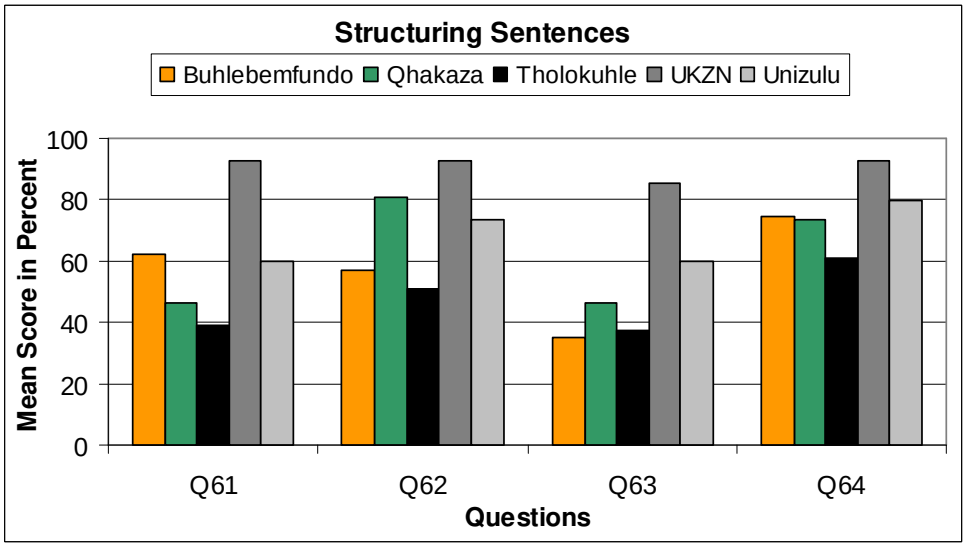

Figure 6.6: Charts illustrating scores on Structuring Sentences represented in percentage.

Question 61 wanted learners to insert into blank space (a) "retards" in order to form a sentence "Refrigerating meats (a) 'retards' the spread of bacteria". The correct answer was secured by 60.2% of all learners with Tholokuhle and Qhakaza attaining low means of 39.2% and 46% respectively. UniZulu had 60%, Buhlebemfundo 61.9% and UKZN 92.5%.

Question 62 needed learners to choose (b) to form a sentence "Throughout the animal kingdom, 'only the whale is' bigger than the elephant. The correct answer was chosen by 69.4% of the participants. Tholokuhle had the lowest mean of 51% followed by Buhlebemfundo with 56.8%. Qhakaza had the mean of 80.8%, UKZN 92.5% and UniZulu 73.3%.

Question 63 majority of students (54.5%) chose the correct answer (b) which helped to construct the sentence "The fact 'that' money orders can usually be easily clased has made them a popular form of payment". Again, learners from high schools performed poorly with 46.6%

for Qhakaza, Buhlebemfundo 35.3% and Tholokuhle 37.2%. Universities had higher means of 85.1% and 60% for UKZN and UniZulu, respectively.

For question 64 learners were supposed to form the sentence "The constitution of South Africa gives parliament 'the power' to pass laws. Majority of learners 74.2% chose the right answer (a). Buhlebemfundo averaged 74.5%, Qhakaza 73.3%, Tholokuhle 60.8%, UKZN 92.5% and UniZulu 79.9%.

6.3.3.2. Written Expressions

Six questions were used to test the ability of learners to give well structured English sentences by identifying the part of each sentence that was not appropriately written (Fig. 6.7). With the exception of UKZN, with the mean of 51.9%, no other school scored above 50%. Buhlebemfundo had the mean score of 34.9 %, Qhakaza 48.8%, and Tholokuhle 46.4% and UniZulu 41%.

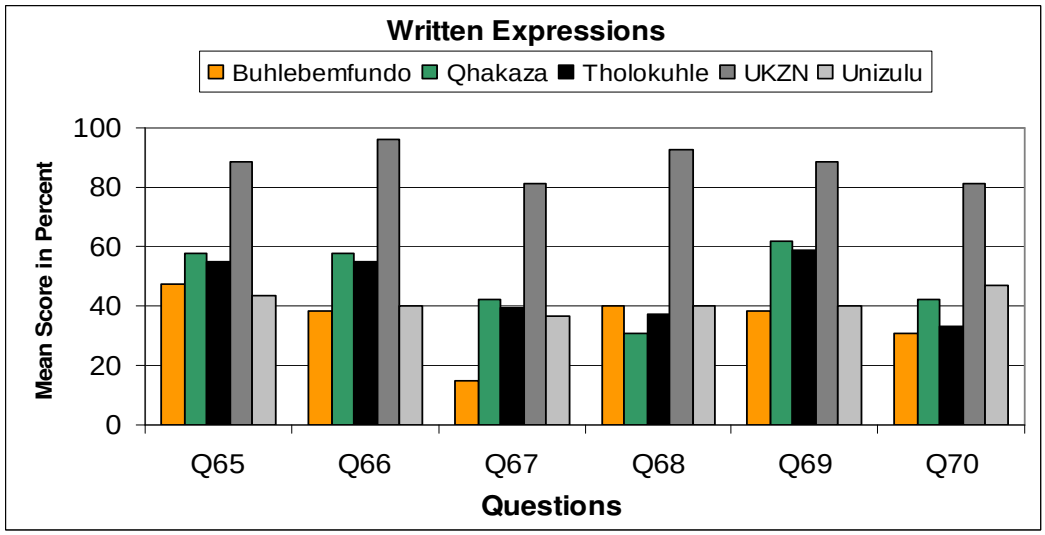

Figure 6.7: Charts illustrating scores on Written Expression represented in percentage

For question 65 the overall mean was 59.5% with Buhlebemfundo averaging 47.3%, Qhakaza 57.7%, Tholokuhle 54.9%, UKZN 88.8% and UniZulu 43.3%. Learners were supposed to choose (c) "with" as it was the word which made the expression wrong.
For question 66 the correct answer was "identification" as it made the expression to be wrong. The overall performance for all schools was 57.4% and UKZN was the highest with the mean of 96.2%. The lowest were Buhlebemfundo and UniZulu with 38.2% and 40%, respectively. Qhakaza had 57.7% while Tholokuhle settled for 54.9%.

Question 67 with the overall mean of 46.8% was poorly performed. All groups excluding UKZN with the score of 81.4% had poor score. Buhlebemfundo had 14.6%; Qhakaza 42.4%; Tholokuhle 39.2%; UniZulu 36.3%. Learners could not discern that the word making the expression wrong was (a) "deficient".

For question 68 (c) "foot" was the incorrect word that made the sentence to lack consistency of numbers. All schools averaged less than 50% except UKZN with mean of 92.5%. Therefore, it was mostly UKZN learners who realised that "foot" referred to the two front feet of the gopher. Buhlebemfundo attained 40.1%, Qhakaza 30.8%, Tholokuhle 37.2% and UniZulu 40%.

For question 69, with the overall mean of 59.8%, Buhlebemfundo scored the lowest marks 38.2%, followed by UniZulu with 40%. Other schools scored above 50% with Qhakaza achieving 61.6%, Tholokuhle 58.8% and UKZN 88.8%. Almost 40% of learners pluralized the name Mark Shuttleworth by choosing (d) "them" which made the sentence incorrect.

For question 70 again, except UKZN with 81.6%, other schools performed poorly and Buhlebemfundo 31% and Tholokuhle with 33.3% were the worst performers followed by Qhakaza with 42.4% and 46.6% for UniZulu. The overall performance for learners was 46.9% and these few realised that (d) "more large" is grammatically incorrect.

The results show that learners could not determine if English expression were well written or not. This explains most learners' inability to communicate in English by the time they reach tertiary education.

6.3.3.3. Reading Comprehension

In this section ten questions were used to measure learners' ability to read and understand short passages similar in style to those found in tertiary institutions. Learners read a passage followed by a number of questions related to the passage. Again, there was poor performance regarding the reading comprehension skills (Fig. 6.8 below). The overall mean for all schools was low at 48.9% with none of the high schools averaging more than 50%. The mean scores were 33% for Buhlebemfundo, 46% for Qhakaza, and 37.7% for Tholokuhle. However, UKZN had 77% and UniZulu exactly 50.6%.

Questions most learners performed well on were those requiring simply pointing to the answer in the passage and not involving any thinking or problem-solving skills.

Question 71 wanted to ascertain whether learners understood the essence of the passage and 68.7% selected the correct answer (b) "Kenyan politics" with all school scoring above 50%. Qhakaza was the highest with 80.8% followed by UKZN with 74%. Buhlebemfundo had 61.9%, Tholokuhle 66.6% and UniZulu with 53.3% the lowest.

Question 72 also wanted to find out what "the word 'they' in line 2" referred to and only 63.8% of all learners chose the correct answer (c) "John and Charles". Only Qhakaza attained a lower than 50% mean of 33% while UKZN was the highest with 92.8%. Buhlebemfundo was 67.4%, Tholokuhle 72.6% and UniZulu 56.6%. For question 73 only 51.1% of all learners gave the correct answered (d) "appealing" which was closest in meaning to "charismatic". The means were high for the universities as UKZN had 74% and UniZulu 79.9% and were low for the high schools as Buhlebemfundo had 21.9%, Qhakaza 30.8 %, Tholokuhle 19.6%.

Question 74 tried to discover what the two men enjoyed and the answer was (a) "the buzz of the city" and 55.8% of all students got it correct. Only Qhakaza and UKZN passed with 61.6% and 85.1% respectively. Buhlebemfundo had the mean of 27.3%, Tholokuhle 33.3% and Qhakaza 43.3%. Question 80 wanted learners to point in the passage where it showed that the bus had problems, and 73.6% of all learners gave the correct answer (c) "line 31". Buhlebemfundo had 34.6%, Qhakaza 80.8%, Tholokuhle 60.8%, UKZN 96.2% and Unizulu 56.6%.
Many second language English speakers gave wrong answers where questions needed inferences to the passage and deeper level of thinking was expected.

Question 75 asked which phrase had the closest meaning to "bumming around" and the correct answer (b) "sitting down and doing nothing", was chosen by 34.7% of the learners with Buhlebemfundo averaging 23.7%, Qhakaza 27%, Tholokuhle 37.2% UniZulu 26.6%, and UKZN - 48.1%. About 42% of learners, Buhlebemfundo's 38.2%, Qhakaza's 65.4%, UKZN's 48.1% and 46.7% from UniZulu, chose the wrong answer (a) "running from place to place" not (b) even though the passage states that the two had lost their jobs and were not doing anything.

Question 76 asked learners to choose the statement the author mentioned as not important in order to change society. The total number of learners choosing the correct answer (b) "fast talking politicians" was 36.8% and only UKZN with 63% averaged more than 50% as Buhlebemfundo had 18.2%, Qhakaza 34.7%, Tholokuhle 19.6% and UniZulu 30%. Many learners chose the wrong answer (c) "representing the voices of the voiceless", for example, Buhlebemfundo 29.1%, Qhakaza 30.8%, Tholokuhle 31.4%, and UniZulu 23.3%.

Question 77 asked students what John and Charles joined. The passage explicitly stated that they joined (d) "one of the opposition parties" and only 57% got that correct. All high schools attained less than 40% on this question with Buhlebemfundo 27.3%, Qhakaza 38.5% and Tholokuhle 21.6%. The two universities had high means, UKZN 88.8% and UniZulu 79.9%. The wrong answer (c) "rioting groups of the village" was selected by Buhlebemfundo's 38.2%, Qhakaza's 34.6%, Tholokuhle's 37.3%, UniZulu's 26.7%, and 11.1% of UKZN's.

Question 78 asked which phrase meant change brought about by the ordinary people and only 33.1% of learners gave the correct answer (a) "change taking place from grassroots level upward". Buhlebemfundo had the mean of 21.9%, Qhakaza 19.3%, Tholokuhle 13.8%, UniZulu 59.2%, and UKZN 40%. An equal number of students (30.3%) chose the wrong answer (c) "relationship is in the eating together" (Buhlebemfundo with 27.3%, Qhakaza 38.5%, Tholokuhle 39.2%, UKZN 33.3%, and UniZulu 13.3%).

Question 79 asked which phrase had the closest meaning to "was out the door" and the correct answer (a) "leaving" was chosen by 53.5% of all learners. Buhlebemfundo scored 25.5%; Qhakaza 53.9%, Tholokuhle 31.4%; UniZulu 88.8%, UKZN 40%.

Question 80 wanted learners to point in the passage where it showed that the bus had problems. The correct answer (c) "line 31" which states that the bus had a flat tyre was chosen by 73.6% of all learners. Buhlebemfundo with 34.6% was the only one that did not get the answer correct. Qhakaza had 80.8%, Tholokuhle 60.8%, UKZN 96.2% and UniZulu 56.6%.

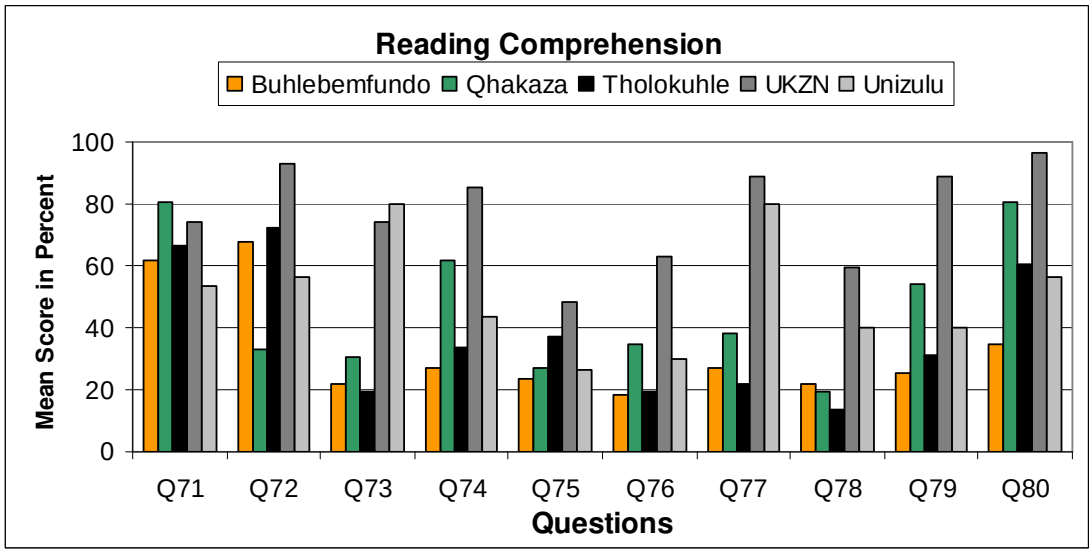

Figure 6.8: Charts illustrating scores on reading comprehension represented in percentage.

6.4. SUMMARY OF RESULTS

Broad investigations were carried out on two important learning skills of literacy and communication and results showed the schools' overall pass percentage of 47.1% on literacy and 52.4% on communication skills. However, for the whole test, i.e. when combining both the literacy and communication components, the overall mean was 50.4%. Due to higher admission scores required by UKZN, their learners performed better than those from the UniZulu and high schools. On the overall performance, apart from UKZN learners obtained a mean of 75.4%, all other schools obtained scores of less than 50% with Buhlebemfundo having the lowest score of 39.9% Qhakaza 47.2% and Tholokuhle 42.7%, learners from UniZulu had the average score of 45.7 (Fig. 6.9).

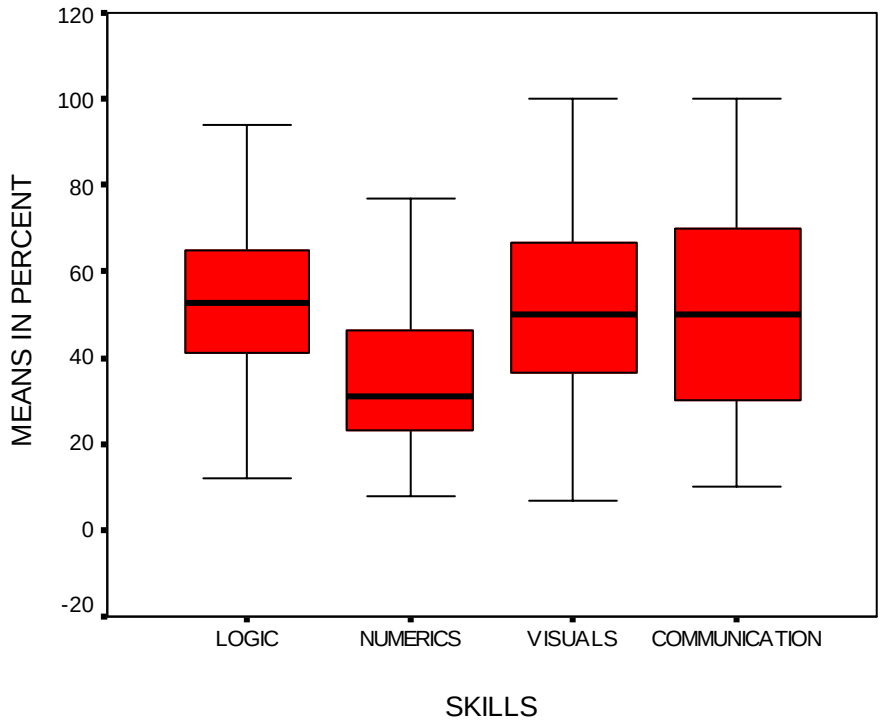

Figure 6.9: Performance of student in different skills.

Literacy comprised of visualisation, logic and numeracy while communication consisted of reading and writing skills. Visualisation skills tested 2D, 3D and 2D – 3D skills. Most students performed well on the 3D skills averaging 62.1%, but had 41.9% on 2D and 42.3% for changing 2D into 3D objects. For logical skills, the overall mean for all schools was 53.4%. On the numerical skills test performance was low at 36.6%. Regarding communication skills, two components of reading and writing were tested and, learners' strength was more on writing with 55.6% and less on reading with 45.2%.

Results show that most learners have generally poor mathematical (36.6%) and reading (45.2%) skills. Even where performance was good the scores barely exceeds the pass mark of 50%, for example, the overall performance for visualisation was 51.4%, logic 53.4% and writing 55.6%. These results reflect the functional skills most young South Africans bring to tertiary institutions (Fig. 6.9).

These results indicate that on the one hand the country's community schools are not producing learners with sufficient skills to function effectively at tertiary level. While on the other hand, the previously blacks only universities are still struggling to compete with institutions such as the UKZN in attracting a higher calibre of learners.

6.5. ANALYSIS OF LITERACY AND COMMUNICATION PROFICIENCY

The Persona Outlining Model's properties are indicators which give a clearer indication of the social and economic background of a learner. Amory and Seagram (2003) state that these indicators need to be taken into account whenever learner assessment is done. Therefore, in analysing POM properties, quantitative analysis was conducted using SPSS (SPSS Inc). The Pearson correlation was used on normally distributed data and the Spearman Rho correlation on data not normally distributed. The Pearson correlation method was used to calculate the linear relationship between the different variables: "The correlation coefficient measures the strength of a linear relationship between two variables. The correlation coefficient is always between -1 and +1. The closer the correlation is to +/-1, the closer to a perfect linear relationship" (http://www.cmh.edu/stats/definitions/correlation.htm).

6.5.1. Literacy

6.5.1.1. Literacy versus Overall Performance

In order to ascertain the importance of functional literacy on academic performance an investigation was carried out to find out if there is a correlation between this and overall performance (Fig. 6.10). The majority of learners did not perform well in the literacy test with only UKZN scoring above 50% on both literacy (73.8%) and overall performance (76.8%). Tholokuhle learners had the lowest literacy mean of 40.5% and overall performance of 42.5%. Buhlebemfundo students scored 42.4% on literacy to 43.1% on overall performance; while those from UniZulu had 44.6% for literacy and 46.5% on the overall performance. Qhakaza participants had a mean literacy score of 45.3% and overall performance of 51.6%.

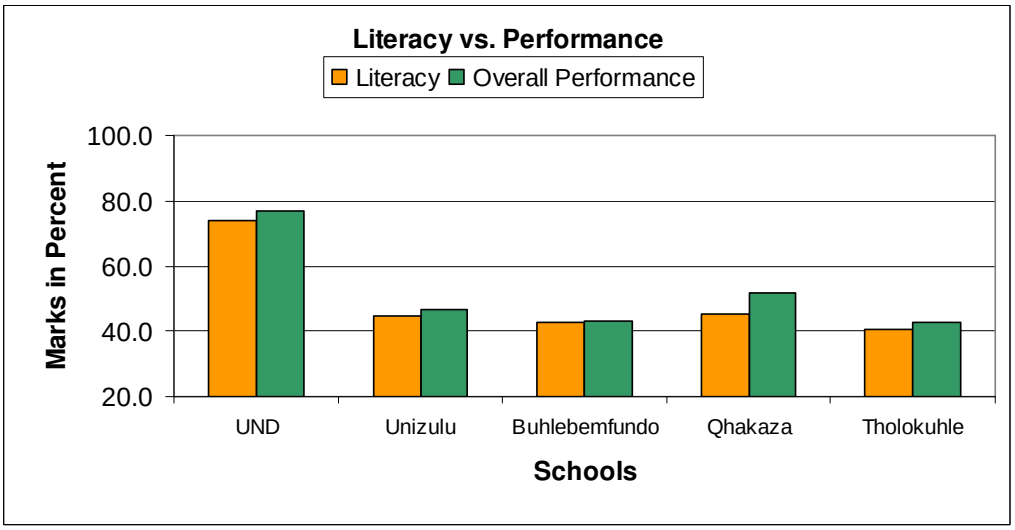

Figure 6.10: Relationship between literacy and overall performance per school.

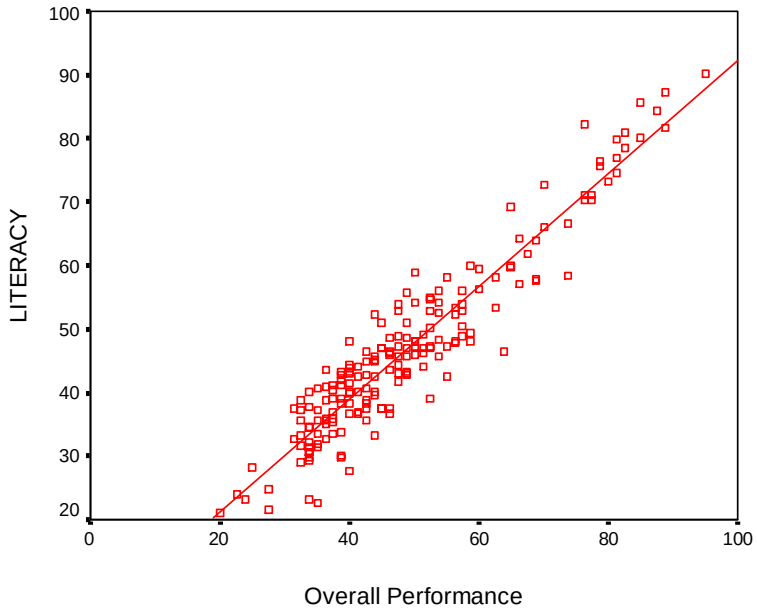

Figure 6.11: Relationship between literacy and overall performance

The Pearson correlation was used to determine whether there was any linear relation between the two skills. The low significance value of $p < 0.0001$ (Correlation is significant at the $p < 0.05$ level, 2-tailed) indicates that the variables are significantly different, however, the high correlation coefficient of 0.909 means that the two are directly positively related. The Scatter Plot (Fig. 6.11) shows the existence of a linear relationship between literacy and the overall means. As the literacy skills improve so is the general performance which means that students with high literacy skills perform better than those with low literacy proficiency.

6.5.1.2. Literacy versus Communication

There was a need to ascertained the correlation between literacy and communication skills as most students who took the test came from backgrounds where English was not just their second language but third or forth language. The Pearson correlation (SPSS) was used to determine any linear relation between the two skills. The low significance value of $p < 0.0001$ indicates that the variables are significantly different. However, the high correlation coefficient of 0.926 suggests that the two are directly positively related, therefore, as literacy is strongly related to communication skill (Fig. 6.12). This indicates that proficiency when learners develop proficiency in literacy their communication skills also improve and vice versa. This is the reason learners from the community schools are poor on both skills while UKZN learners demonstrated high competence levels on both skills.

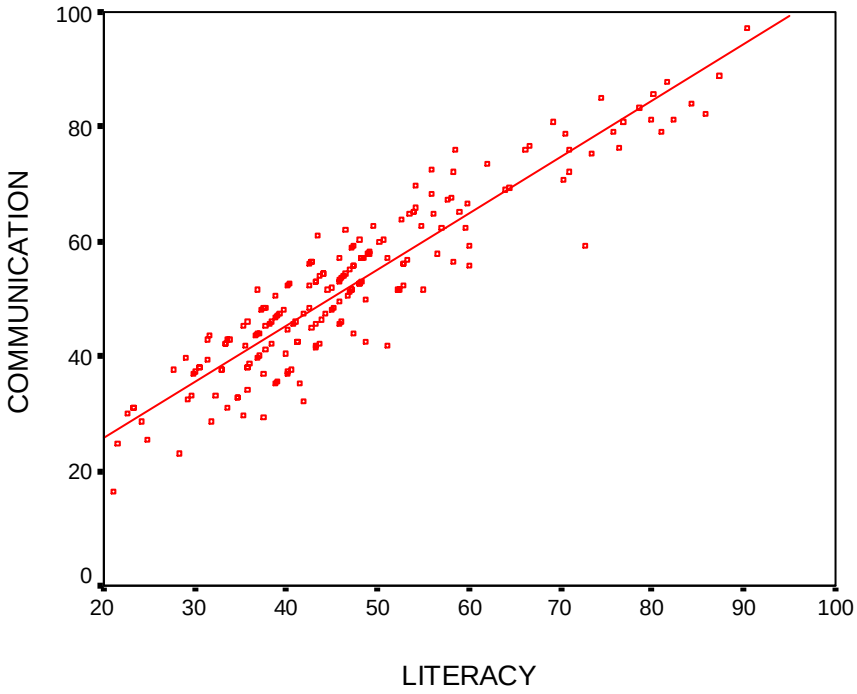

Figure 6.12: Relationship between literacy and communication

6.5.1.3. Literacy and Gender

An investigation was undertaken to determine whether gender has any significant role in the literacy performance. The results indicate that literacy performance by gender is skewed towards males who attained a mean score of 46.4% while their female counterparts had 44.8%. The UKZN males had the highest literacy score of 74.6% followed by UKZN females with 71.2%. Tholokuhle females had the lowest mean score of 39.8%, followed by Qhakaza males

with 41%. UniZulu females had literacy mean of 41.2%, UniZulu males 45.2%, Buhlebemfundo females 42.6%, Buhlebemfundo males 42.3%, Qhakaza females 48.5%).

In order to determine the correlation between the performances of the different gender groups the Independent Samples t-test, which compares the two group means, was used and equal variances for both groups were assumed because of the low significant value of $p < 0.004$ on Levene's Test. Because of the high significance value ($p= 0.1449$) and the confidence interval (-7.16377 and 1.060968) the two groups were not considered any different. Therefore, regarding the performances on literacy by the two sexes, the t-test shows that they are not statistically different (Fig. 6.13).

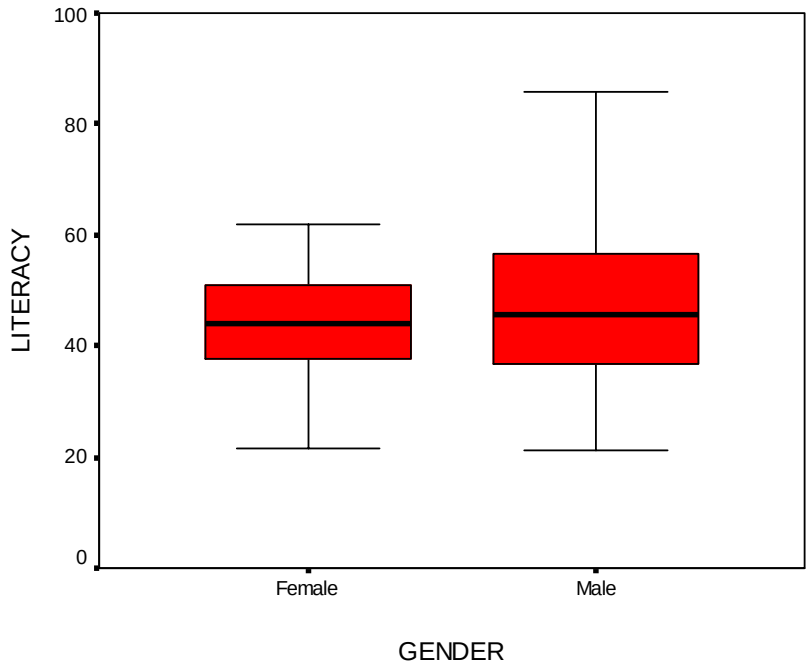

Figure 6.13: Representation of performance on literacy skills by gender.

Three aspects of literacy were examined in this study and these are visualisation, numeracy and logical skills as discussed below.

6.5.1.4. Visualisation Skills

The Pearson correlations results between visualisation and logical skills was (0.270) and visualisation and numerical (0.257), and visualisation and communication (0.287) illustrating that there exist a weak linear correlation between these variables. The low significance levels between visualisation skills and these skills (all with $p < 0.001$) indicated that all groups were significantly different.

The role of gender in articulating the visual world was assessed and females obtained 53.3% outperformed their male counterpart who scored 50.1% (Fig. 6.14). The results were subjected to the Independent Samples t-test, which compared the two means was carried out and the unequal variance was assumed because of the high Levene's test. The high significant value for the t-tests (p = 0.271) and the confidence interval which contains zero (-0.737 and 2.608) meant that performance for the two groups was not significantly different.

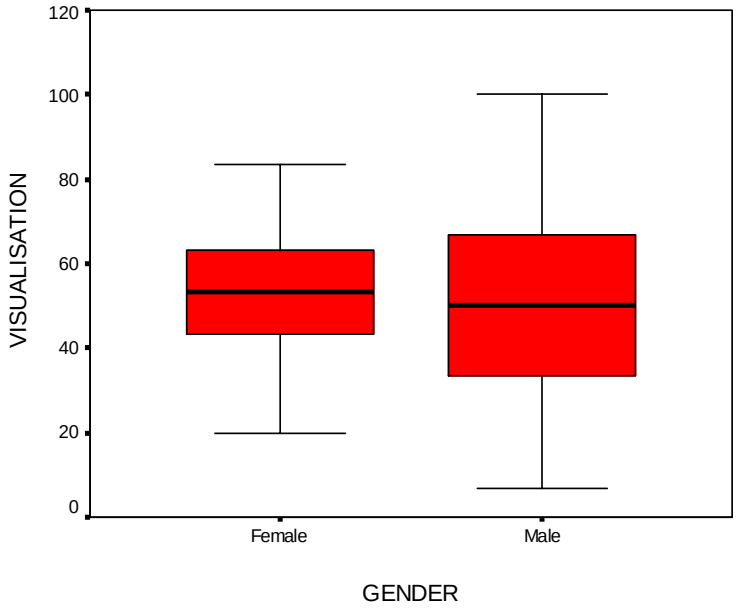

Figure 6.14: Representation of performance on visual skills by gender.

Regarding the three different components of visualisation (2D, 3D and 2D – 3D) more analyses were undertaken to investigate the relationship of gender and these skills. The overall means for 2D skills were 42% for females and 41.7% for males. Regarding the 3D skills, the overall mean was 59.5% for females and 64.2% males. When 2D and 3D tests were subjected to the Independent Sample t-test, the unequal variances for both means were assumed because of the high significant value on the Levene's test of p = 0.293 for 2D skills and p= 0.624 for 3D skills tests. The high significant values for the t-tests of p= 0.943 for the 2D and p= 0.173 for the 3D coupled with the presence of zeros in the confidence intervals for 2D (-0.627 and 0.674) and 3D (-1.592 and 0.288) demonstrated that there was no significant difference between performances of the two genders. These results confirm assertions made by Burin *et al.* (2000) that research on "visualisation factor" had not shown any differences between the genders or at times "the difference is small". Burin *et al.* (2000) explain that there are many ways of solving 2D problems and men and women may differ in their approaches but would still arrive at the same result.

Osodo (1999) found that male students were more ably to mentally rotate 3D objects than their female peers. These results are also supported by Burin *et al.* (2000) who agreed with the established norms that the skills to rotate 3D objects favours males. However, the results for 3D rotation in this study indicate that performance between these genders is not significant different (t-tests show negligible difference between the 3D skills means of 4.78 for males and 4.76 for females).

Regarding changing the flat 2D objects to 3D objects (2D - 3D) the t-tests results show different means for both genders (females 3.63 and males 4.21). Only university students passed in this section (UKZN: Females 57.1% and males 80% and UniZulu: Males 50% and females 50%). No school students passed as they all obtained means below 50% (Qhakaza females 23.5%, Qhakaza males 27.4%, Tholokuhle females 36.1%, Tholokuhle males 42.4%, Buhlebemfundo females 25.5%, and Buhlebemfundo males 44.2%) (Fig. 6.15).

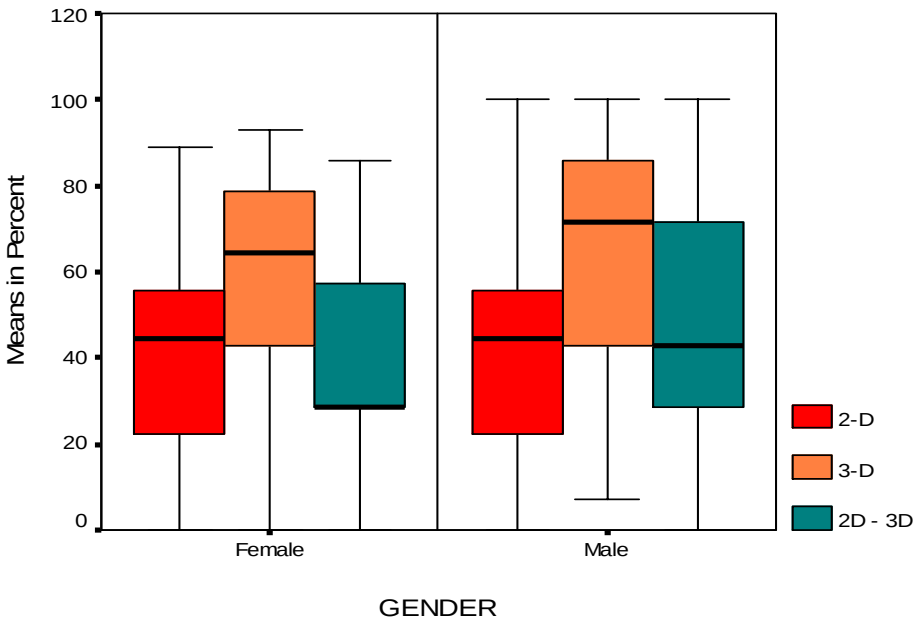

Figure 6.15: The Box plot showing the means on visual skills for both gender.

The Independent Sample t-test gave a low significance value (p = 0.0361) in the Levene's test, leading to the assumption that the two means for both sexes were equal. However, the t-test gave a low significance value of p = 0.039 and the absence of zero in the confidence interval (-1.144 and -.018) illustrated that there was a significant difference between the two genders

regarding their ability to transform 2D planes to 3D objects with males more mentally able to transform 2D objects into 3D objects than females.

6.5.1.5. Logical Skills

The correlations between the logical skills and other skills are varied as some showed strong and others weak linear relationship. According to the Pearson correlation test the relationship between logical and numerical skills is weak (0.556), the logic and communication relationship demonstrated a strong correlation (0.757) and the correlation between logical and visualisation skills (0.183) is not significant. The significance levels between logical skills and the other skills (numerical and communication) was $p < 0.001$ and between logical and visual skills $p = 0.012$. These low significant values illustrate that the groups were significantly different. Therefore, there is a strong positive correlation between logical and communication literacy while logical and numerical skills give a weak correlation. However, there is an insignificant relationship between logical skills and visualisation skills (Fig. 6.16).

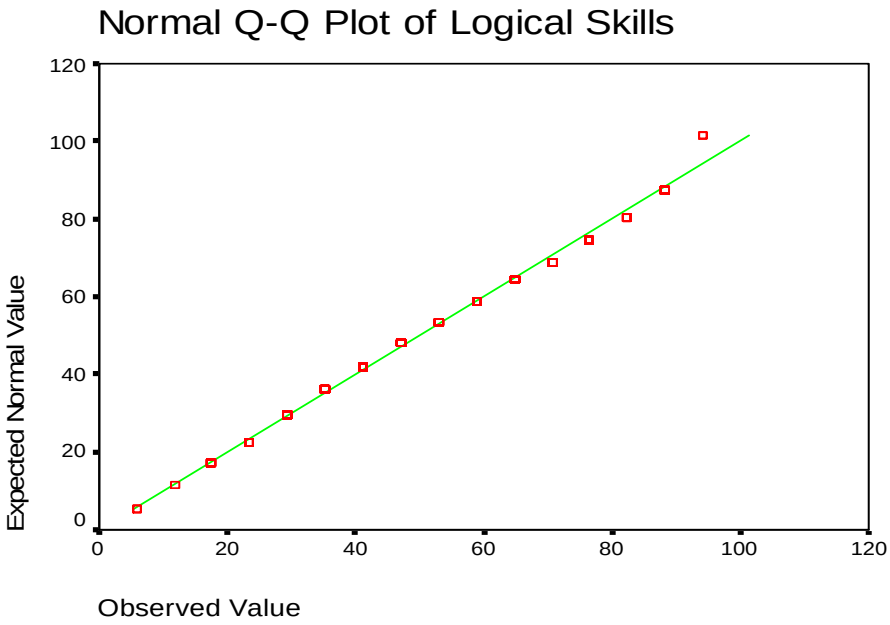

Figure 6.16: Illustrate the normal distribution of learners' logical skills.

6.5.1.6. Numerical Skills

The Pearson correlations between numerical skills and other skills are relatively weak for numerical and logical skills (0.556) and for numerical and communication (0.509). The correlations are linear and positive but are very weak between the numerical skills and logical

and communication skills. Again the low significance levels of $p < 0.001$ between the numerical skills and other skills indicate that the skills are significantly different. The exception was with the relationship between numerical and visualisation skills at $p = 0.257$ and with the significant value of $p < 0.001$. This demonstrated that there is no significant association between the two variables (Fig. 6.17).

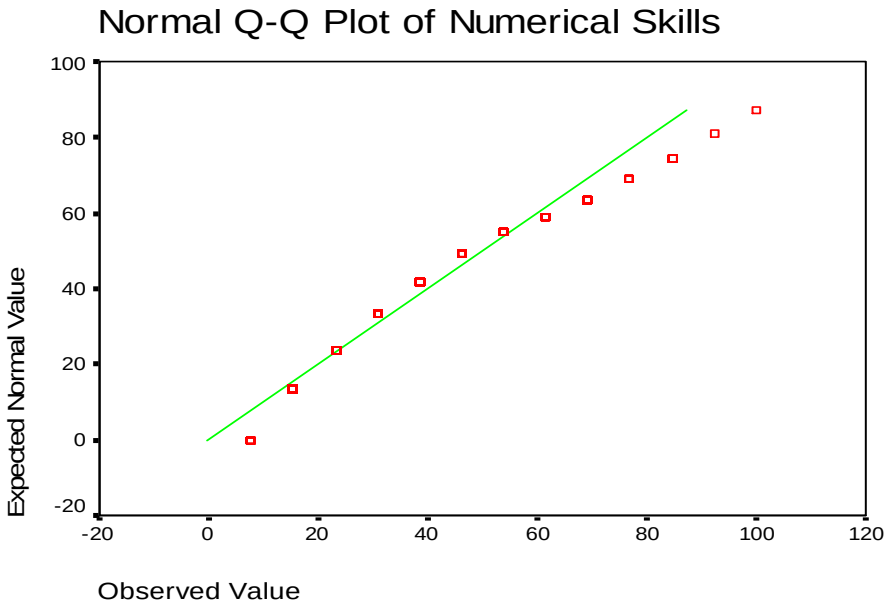

Figure 6.17: Normal Q-Q graph showing the distribution of learners' numerical skills.

6.5.2. COMMUNICATION SKILLS

6.5.2.1. Communication vs. Overall Performance

Comparing how communication skills affect the overall performance the results indicates that there is a direct relationship between the communication and the overall performance. Students with good communication seem skills (English in this instance) perform better at school than those who have low communication skill levels. However, only Buhlebemfundo's students had a worse communication results (38.5%) than their overall performance marks (43.1%) which could be a reason why they performed so poorly (Fig. 6.18). Learners from other schools had slightly higher communication results than overall performance marks with UKZN the highest with communication 83.5% and overall performance 76.8, UniZulu (communication 47.7% and overall performance 46.5%), Qhakaza (communication 55.6% and overall performance 51.6%) and Tholokuhle (communication 44.6% and overall performance 42.5%).

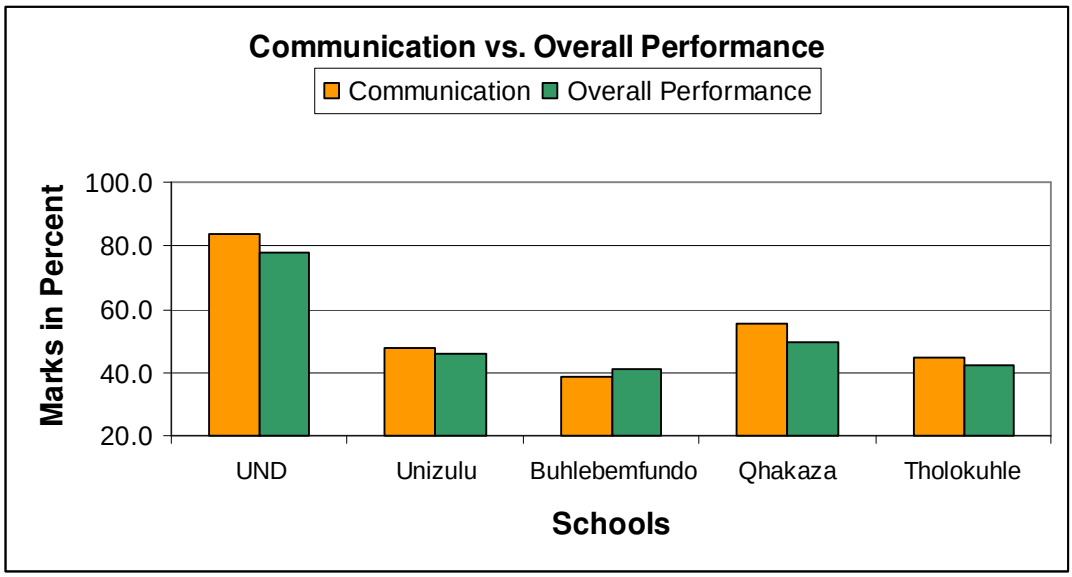

Figure 6.18: Comparing means for communication and overall performance

The results were subjected to the Pearson Samples t test in order to determine the correlation between the communication skills and the overall performance. There was a strong positive correlation between communication and overall performance (0.921). The significant difference between the two means was $p < 0.001$ indicating that the variables were significantly different. There is a strong positive correlation between communication and the overall performance (Fig. 6.19).

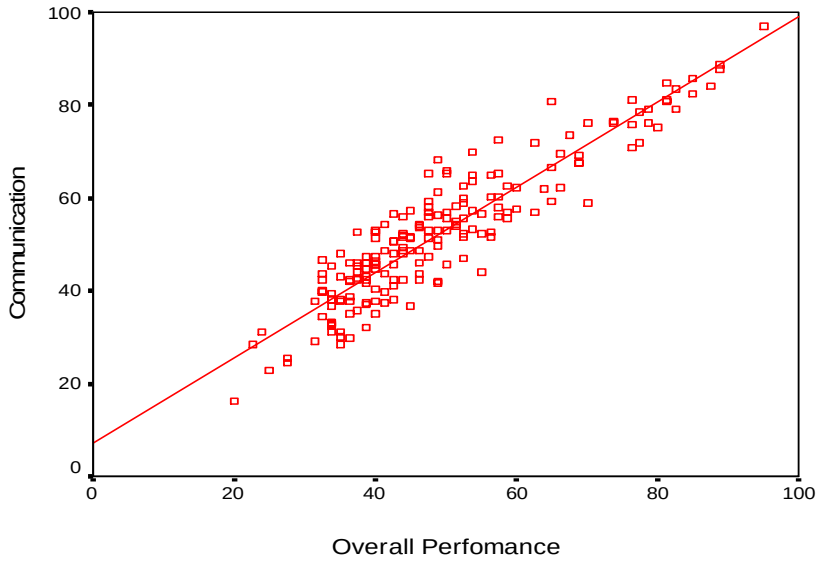

Figure 6.19: Learners' communication versus overall performance.

The following section attempts to establish whether there is any relationship between communication and the different skills. The Pearson correlations show strong linear relationship

between communication skills and some of the skills with the exception of the numerical skills. There is a strong positive correlation between communication and logical skills 0.742, and communication and visualisation skills 0.763. However, there is a weak association between communication and numerical skills (0.509). The significant differences between communication skills and other skills were all $p < 0.001$ indicating that the variables were significantly different. The significant difference was measured at less 0.05. These direct positive correlations signify that as communication skills improve or worsen even the other skills do improve or deteriorate. However, the rate of change between communication and numerical skills is not evident in some instances due to the weak relationship between the two. The Fig. 6.20 demonstrates the relationships based on the means acquired by the learners.

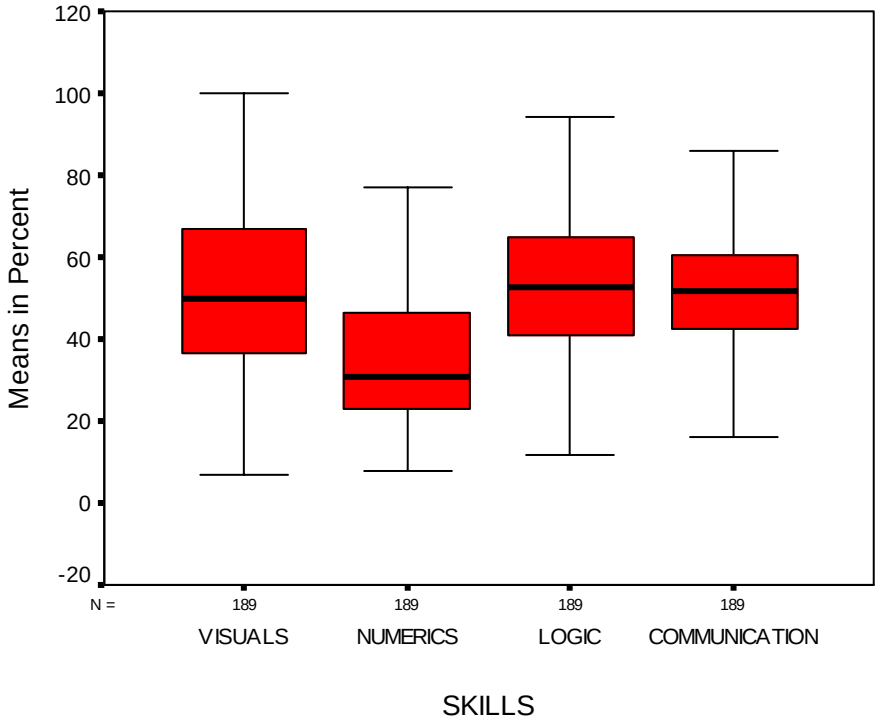

Figure 6.20: Means for the four skills associated with literacy and communication

Comparing each of the different skills to the communication skills the results show a low significant value of $p < 0.001$ suggesting that performance in these skills are significantly different. However, the reason for these results could be related to language skills as it could be argued that results for these tests require proficiency in English which is not the mother tongue of most of the learners who participated in the study.

6.5.2.2. Communication and Gender

Regarding communication and the performance of the different genders the overall means show that males with 53.8% outperformed their female counterparts who had the overall mean of 45.9% (Fig. 6.21). UKZN males had the highest mean score of 84.8% followed by UKZN females at 80%. The worst scores were from females from Buhlebemfundo and UniZulu with 37% and 38% respectively. Buhlebemfundo males had 40.7% and UniZulu's 49.6%. While Qhakaza scored, females 54.7% and males 57%, and Tholokuhle females 43.8% and males 45.2%.

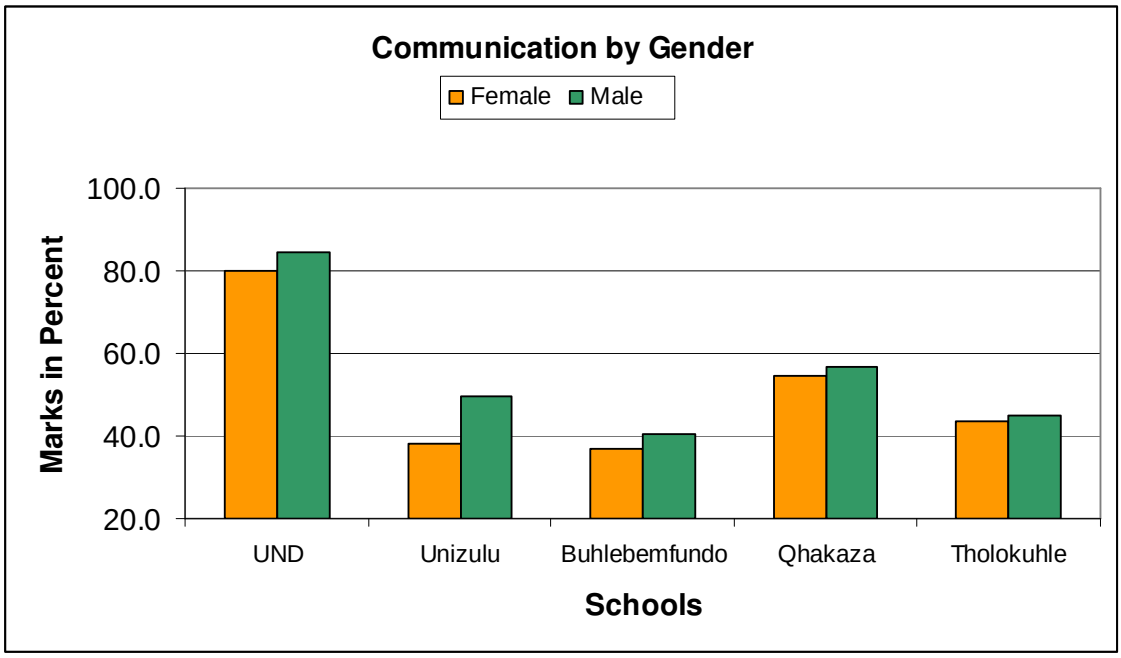

Figure 6.21. Performance in relation to communication and gender.

In order to determine whether there is a correlation between gender and performance in communications skills test an Independent Samples t-test was used and unequal variances for both groups were assumed. Because of the high significance value (p= 0.106) in the Levene's test the unequal variances assumption was made. The t-test gave a significant value of p = 0.923 and the confidence interval containing zero (-10.79943 and 9.77368) which indicates that the two groups were not significantly different. Therefore, gender does not have any bearing on the communication skills of these learners.

6.5.3. OTHER POM PROPERTIES

The following section deals with the second part of the POM instrument and researched other factors which might affect performance of learners such as their social and economic

background and this includes: (i) Household income; (ii) Standard of living index (comprises mainly the households possessions); (iii) Home language and (iv) Education of family members.

6.5.3.1. Household Income versus Performance

Households incomes varied substantially (Fig. 6.22). The largest category of students (45.2 %) came from families earning less than R15,000 (15K) per annum. Students coming from families earning between 15K and 50K made up 18% of the sample, while students coming from families with annual earnings of between 50K and 80K and above 80K made up 21.3% and 15.4% of the sample respectively.

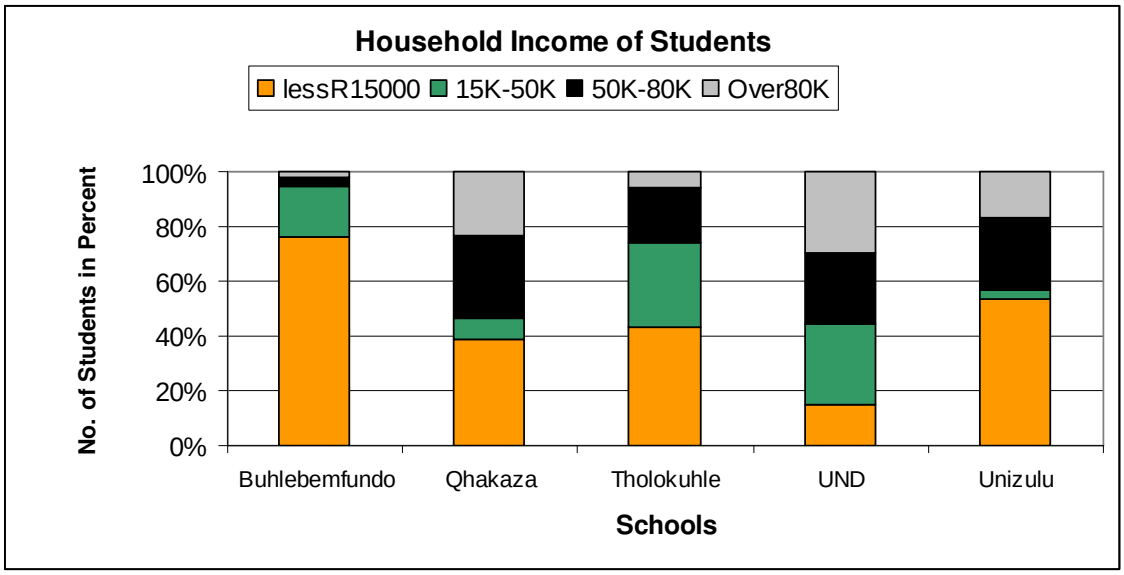

Figure 6.22: Analyses of the financial background of learners according to schools.

With the exception of UKZN students with 14.8%, most students came from households with combined salaries of less than R15K per month (Buhlebemfundo 76.4%, Qhakaza 38.5%, Tholokuhle 43.1% and UniZulu 53.3%). The distribution of salaries among UKZN learners' households was uniform across the three top categories with 29.6% earning between 15K and 50K, 25.9% between 50K and 80K, and 29.6% over R80K. Buhlebemfundo had 18.2% of its students coming from families earning between 15K and 50K, Qhakaza 7.7%, Tholokuhle 31.4%, and UniZulu 18%. Those earning between 50K and 80K Buhlebemfundo had 3.6% Qhakaza 30.8%, Tholokuhle 19.6%, and UniZulu 26.7%). With incomes above 80K Buhlebemfundo averaged 1.8%, Qhakaza 23.1%, Tholokuhle 5.9%, UniZulu 15.4%.

The Independent Samples t-test was used to compare the means of students from different salary categories to determine whether family income has any influence on performance. The results show that performance and salary are directly related. The results indicate that with an

increase in the household income performance also improves. For salary groups closer to each other the difference is smaller. For example, comparing learners from households earning less than 15K with students from the 50K-80K bracket the t test indicates that there is significant difference with those who are well off performing better with mean difference of 6.031. The significant value of p = 0.0273 and the absence of zero in the confidence interval (1.3412 21.7392) again illustrate that the two performances were significantly different. However, the gap increases even more (17.57) when the comparison is with the income bracket of over 80K. The low significant value (p = 0.001) and confidence interval containing no zero (7.9911 and 27.1513) meant that the difference is substantial. These results are illustrated in figure 6.23.

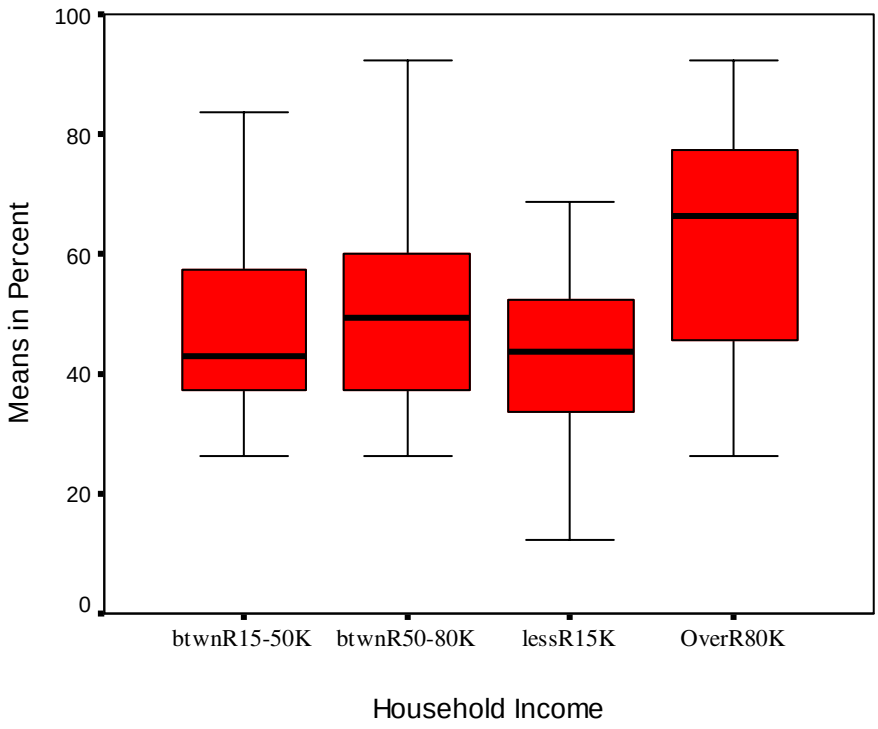

Figure 6.23. Analyses of performance in relation to family income.

6.5.3.2. Parents' Education versus Performance

Most students came from households with low levels of education, that is, where in majority of instances both parents did not have a high school certificate. The t-test analyses (p = 0.007) show that learner performance is directly related to parent education level. For example, the t-test shows that learners (mean score of 62.53%) whose mothers have a university degree performed better than those (mean score of 45.77%) whose mothers have a matric certificate only. Comparison between student performance and the education level of the father resulted in a similar result. However, performance was similar with no significant difference for those

students whose parents either had a matric (grade 12) or grade 10 certificate. The results, therefore, indicate that learners with uneducated parents do not perform as well as learners with educated parents.

6.5.4. The Standard of Living Index

The presence of any eleven household items, typically found in urban and semi-urban South African homes, is used to define a Standard of Living Index (SLI). This index consists of the following items: electricity, running water, car, fridge, microwave, television, cell phone, Telkom phone, computer, laptop and Internet connection. An index of zero therefore represents a low economic status and an index of 11 represents a high economic status.

The results show that a number of items in a household do not have any significance on the performance of students (Fig 6.24). For example learners from households with one item (Item1) averaged 39.8%, those with 2 items 53.6% while those with items seven equalling 46.2%. Over 90 percent of students come from households where there is running water (96.3%). Most had accesses to a cellular phone (91.5%) and 8 out 10 learners (81%) have land telephones in their homes. However, only 18.5% have access to computers, 10.1% to laptops and only 5.8% of the sample have access to the Internet. The number of households with cars is 25.4%, fridges (49.7%), microwave (27%) and television sets (54%).

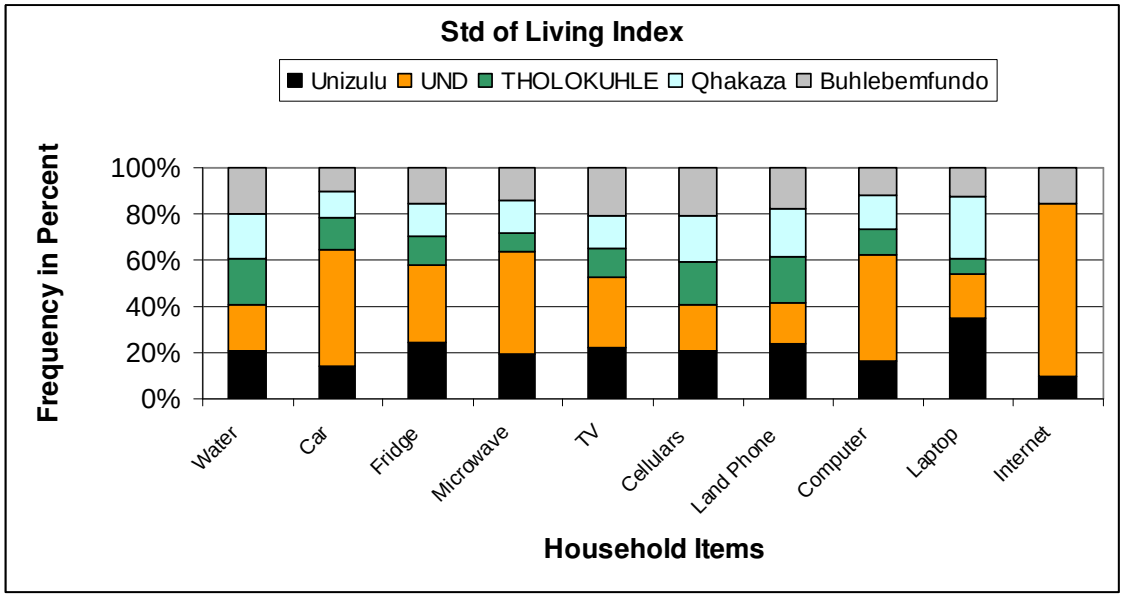

Figure 6.24: Analyses of the Standard of Living Index

Therefore, in order to measure the association between a number of items in student's household and their performance, Spearman's Rho correlation was performed. This test indicates that there is no association between what students have in their household and how they perform in class. The correlation was very weak at a -0.077 indicating that there was no correlation between the number of items and performance. Thus, there appears to be no relationship between SLI and performance.

6.5.5. Home Language versus Performance

The Spearman Rho correlation method was used to determine the effect of language (English versus isiZulu) on performance as data were not normally distributed the Levene's t-test was used to determine the equality of means. Analyses showed that there was a significant difference in performance between English and isiZulu speakers: there is a weak linear negative correlation between home language and the performance, visualisation (-0.339), logical (-0.476), numerical (-0.339) and communication (-.492) skills; the small significance levels ($p < 0.001$) indicate that home language and performance are significantly positively correlated and language and the skills are linearly related. English language speakers performed better than isiZulu speakers in all the different categories, e.g. visualisation (75.9% to 48.5%), logical (77.4% to 49.8%), numerical (65.7% to 32.7%) and communication (85.4% to 45.2%). Therefore, there is a strong relationship between performance and fluency in speaking English.

6.5.6. Number of Siblings versus Performance

The Pearson correlation method was used to calculate the linear relationship between the number of sibling and the different skills. The low significance value between the number of sibling and numerical ($p < 0.001$), communication ($p < 0.001$) logical ($p < 0.001$) skills and visualisation ($p = 0.033$) skills indicate that the number of siblings appears to influence performance. However, the correlations between siblings and performance are weak. On the overall performance, the significant value of $p = 0.00015$ indicates that the differences in performance significant. The Pearson correlation (-0.2723) shows that the relationship is weak.

6.6. REFLECTION AND DISCUSSION

"Education lies at the foundation of many issues in South Africa today" (Anderson *et al.,* 2001). These authors also state that it is not possible to investigate racial, social and economic issues without looking at the role of education. The current study indicates that such socio-economic issues do play a significant role in the way learners perform at school. In a discussion on spatial visualisation in engineering, Strong and Smith (2002) argue that the "ability to perform complex

mental manipulations of objects has been established as a predictor of success in several technology related disciplines". Shalla and Schellenberg (2001) found that 50% of Canadians living in low-income households have low-levels of literacy compared to 8% of those with high-literacy levels. It is, therefore, often difficult to divorce the relationship between race, earnings and school performance.

Race and economic status appear to be directly related to school performance. Van der Berg (2002) reports that from literacy and numeracy tests conducted in 1993 with 12-18 year olds both black and white students performed badly; also while black students averaged 78% of white years of education, their literacy and numeracy scores were 55% and 47% of the white levels respectively. However, in academic terms 55% and 47% are significantly different as they can determine who could be admitted at tertiary school. It is for this reason that scholars such as Corley (2003) argues that race appears to be a persistent factor in employment statistics, educational attainment and the acquisition of literacy skills, with significantly higher unemployment rates and lower educational attainment rates among Black and Hispanic Americans than among White Americans. However, Luckett (1995) contends that gender and race, socio-economics, access and curriculum are the major factors involved in poor performance.

Schäfer (2003) working with secondary schools in the Eastern Cape found that rural, or township, schools performed poorly in spacial and visualisation constructs. Also, rural schools performed poorly in 3D problems and those characterized by special orientation constructs. In this study, it was found that most learners lacked skills to comprehend the combination of rectangles, circles and/or triangles. They also lacked the ability to visualise rearranged objects; participants performed better in questions related to 3D than to 2D visualization; and that learners from UniZulu and the three secondary schools lacked the ability to visually transform 2D flat sheets into 3D objects. In every case participants from UKZN outperformed scholars from other groups in the tests associated with visualization.

Anderson *et al.* (2001) found that there are no gender gaps in South African schooling but that there is a racial gap that is influenced by school quality (i.e. economics). This was also discovered by Osodo (1999) who found that White learners performed better than their Indian and Black counterparts did in visualisation skills and that Black and Indian learners were better in 3D than in 2D visualisation skills. Osodo (1999) also found that Black and Indian students improved their visualisation skills with increased exposure to visual objects and advances in their studies.

One of the most valuable sources of data on education is household survey data (Anderson *et al.*, 2001). In this regard, Schäfer (2003) found that there was a high correlation between poor performance and poor socio-economic background. Such a relationship may explain the difference found in this study. Strong and Smith (2002) state that age, gender, individual differences, experience of sufficient length may improve performance. Thomas and Higbee (1996) argue that educators need to change their techniques in the classroom to incorporate a variety of methods which include those that stimulate visualisation skills. The Pearson correlations between the visualisation test and those for logical (0.183), numerical (0.257) and communication skills (0.777) were similar and significant at the 0.01 level; while between visualisation and family income (Pearson Correlation -0.008) there was no statistical relationship. Therefore, it appears likely that visualisation skills may be related to prior experience and that educational practice should include many such activities to overcome this problem.

In a recent study in Ghana, Blunch (2002) found that cultural norms and background were important determinants of literacy and cognitive skills and that females were far less likely to be literate than males. This is supported by Amorim *et al*. (2004) who stated that for any training to be effective facilitators should be well aware of the backgrounds and contexts of the participants, such as age, religion, geographic location, culture or personal experience, etc. The results attained in the present study confirm the assertions made by Blunch that the level of parents' education also plays an important role in the development of children's literacy and cognitive skills as the results showed that performance was higher for children from families with more educated parents. The results illustrate those learners who come from the higher income brackets perform better than those coming from families that are poor. The gap increases directly with the income gap. The study also shows that performance of learners is high among learners whose parents are educated. Anderson *et al*. (2001) state, "It is not clear what causal mechanisms drive this relationship". However, these authors argue that such results may be due to the ability of parents to help their children with their schoolwork or it may be that such families live in better neighbourhoods with better amenities and schooling facilities which influence the children's performance at school.

Results from this study found that for the section on numeracy and logic participants scored an average of 46%. Many, but not all, UKZN learners were able to answer most of these questions. With respect to literacy (reading and writing) learners performed well in structuring sentences but many were weak in constructing simple present tense sentences. Most learners were not able

to tell if expressions were well written. Results from the reading comprehension also indicate that South African learners cannot read and understand short passages; especially learners are not able to make sense of meaning by inference. These results, especially those from university scholars, are difficult to explain fully. Literacy rates have increased by 10% over the past 10 years (EarthTrends Country Profile, http://earthtrends.wri.org). However, Pearson correlations between communication skills and visualisation (0.777) and between communication skills and logical (0.757) were quite high which meant that there was a strong positive linear relationship between these skills. The correlation between communication and numerical skills demonstrated a positive linear relationship of 0.509. For the mathematical proficiency test questions were written in English, which could lead to the argument that poor performance in this skill is a result of poor understanding of the English language (communication skills) used by most learners. However, factors other than language are also involved, as there is also a strong relationship between communication and visualisation, which did not require the use of English. Spearman correlations between home language and visualization, logic, communication and numeracy were -0.339, -0.476, -0.492 and -0.448 respectively. English speakers also performed better than did isiZulu speakers. However, factors other than language might be involved as numerical and visualisation skills appear to be strongly related to home language.

The results also indicate that there may be a fundamental problem with the educational system as the system does not fully equip learners with basic skills. Learners go through 12 years of primary and high school education without learning visual, logic, numerical, reading, and writing skills. While the socio-economical status of participants may influence their performance, it is necessary to seek ways to transform the educational practices. It is suggested that a more social constructivist approach to learning in primary and secondary schools might assist learners in promoting participation, hands-on approach and communication. In addition, the issues related to language competency need to be addressed as these might affect other skills.

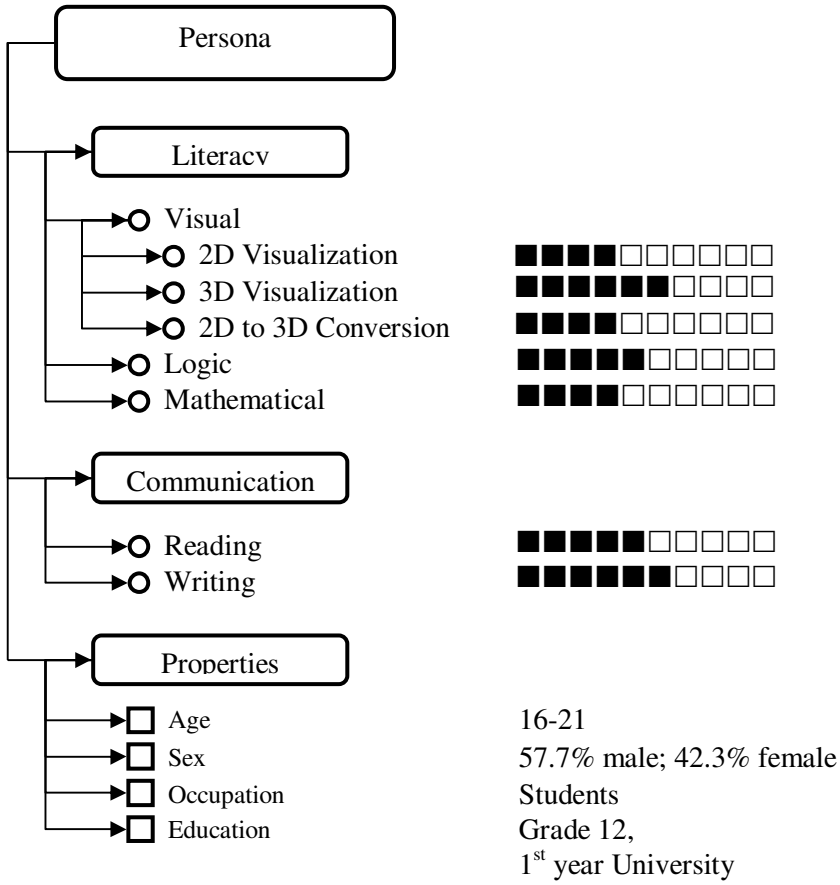

Figure 6:25: Addition of quantified and demographic data to describe the Persona Outlining Model.

Newman and Lamming (1995) propose the use of fictitious user, or persona, in the development of software. However, Amory and Seagram (2003) argue that persona data are not built from real data (both quantitative and qualitative) and can, therefore, not be subjected to vigorous evaluations. The results obtained using an instrument designed to evaluate basic skills could also be used to describe the Personal Outlining Model in terms of real data (Fig. 25). Such a visualization clearly indicates the average skills (3D visualization and writings), and those that need particular attention (for example, mathematics).

Therefore, POM allows us, through research, to provide a persona definition that forms the basis to determine effects of the use of interactive and other learning resources. Results from this instrument have provided insights into the skills of many young South Africans. POM proved to be a useful theoretical basis for the design of the instrument and allowed us to quantify the characteristics of our intended audience. However, such qualitative data should only be used in conjunction with other qualitative and quantitative assessments as suggested by Reeves (2000).

6.7. CONCLUSION

The results presented above reflect the socio-economic problems faced by education in South Africa. Students from the University of KwaZulu-Natal performed better than those from the University of Zululand and from the three high schools of Buhlebemfundo, Qhakaza and Tholokuhle. Most learners from UKZN study in their home language, which is English, and many of them come from families where at least one parent has a tertiary qualification. On the other hand, all learners from the three community schools study in a foreign language, which they only use in the classroom. For most learners English is not even their second language as they spoke other African Languages. A majority of South African learners come from homes whose household language of communication is not any of the two major European languages mainly used in our tertiary institutions, which are English and Afrikaans. This could have contributed to the poor performance in skills not usually associated with language such as visualization and logic.

It is therefore, not surprising that the results from the literacy and communications tests indicate that students enter tertiary education lacking the general skills which are necessary for their academic survival. The two main skills which learners lacked most are mathematical skills (overall mean 36.6%) and Reading (45.2%). Poor performance on these skills highlights problems existing within the South African education system underpinned by the underpreparedness of learners to confidently part-take in tertiary learning.

Other findings portray that there is a direct and very strong relationship between communication skills and learners' performance (correlation coefficient 0.921) and between the literacy skills and learners' performance (correlation coefficient = 0.909).

There is, among these participants, also a weak correlation between numerical and logical skills and between numerical and communication skills. The reason for these relationships could be the strong presence of written language in numerical and logical skills. However, there is an insignificant relationship between visual skills and numerical skills. The results indicate that performance is highly influenced by the family income. Learners who come from families and communities that are well off performed better than their colleagues from the underprivileged backgrounds. This is illustrated by the poor performance of learners from the University of Zululand who came mainly from the underprivileged backgrounds compared to those who attended UKZN who were mostly from economically well off backgrounds.

Family size and the standard of living appear not to influence performance. Also, both genders appeared to perform in a similar manner except that male participants were more able to transform 2D planes into 3D objects more proficient than their female counterparts.

Again, results presented here indicate that South African learners from community schools such as Buhlebemfundo, Qhakaza, and Tholokuhle, and previously blacks only tertiary institutions such as University of Zululand, do not have the necessary skills to participate in tertiary education and lack many of the basic skills required to be part of a thinking society.

The section has developed and evaluated an instrument to assess learning skills using POM. In the following sections (Chapters 7 and 8) the importance of computer games in learning is investigated. The first part of Chapter 7 investigates how an adventure game *Zadarh* can be used to overcome misconceptions related to photosynthesis. Insights developed during the *Zadarh* investigation are then used to evaluate skill development that occurs while playing *γKhozi* in the second part of the chapter. Chapter 8 is the synthesis of the overall findings and provides recommendations for further studies.

CHAPTER 7
THE USE OF EDUCATIONAL GAMES IN EDUCATION

7.0. INTRODUCTION

The aims of this part of the study were to: (i) Ascertain the practical use of computer games, as learning tools, in urban and semi-urban areas; and (ii) Evaluate the academic effectiveness of games to promote the development of cognitive, academic and social skills. Therefore, the research reported in this chapter attempts to investigate the effectiveness of new approaches to learning and teaching which incorporates the use of play includes three iterations through the development research cycle. The first two iterations investigate the use of *Zadarh, an adventure game,* specifically designed to address misconceptions related to photosynthesis and respiration. The last iteration of development research cycle uses another adventure game *γKhozi* to investigate the development of player's problem solving skills.

7.1. STUDY OBJECTIVES

The primary objective of this study, therefore, was to determine the educational value of games where a sample of participating learners came from a wide range of backgrounds. The secondary objective was to assess the applicability of the use of educational games to adequately address learner misconception while enhancing their problem solving skills such as literacy, communication, memory, etc.

7.1.1. Objective of *Zadarh*

The aim of playing *Zadarh*, and educational adventure game, was to investigate its use to overcome misconceptions related to photosynthesis and respiration in learners from urban and semi-urban environments. The game was played individually and in groups or pairs. After playing *Zadarh* learners were requested to answer questions on the topics of photosynthesis and respiration using paper-and-pencil test and oral test in some cases.

7.1.2. Problem Analysis

Most students, at all educational levels, enter the classroom with mental models of phenomena that may be at variance with accepted scientific models of those same phenomena (Michael**,** 1998). Studies reveal that these misconceptions are difficult to get rid of once harboured. However, Adams (1998) found that students who had played *Zadarh* demonstrated a much clearer understanding of the complementary relationship between photosynthesis and respiration, than did students who have not played the game. Therefore, this part of the study

investigates the use of *Zadarh* to overcome misconceptions related to photosynthesis and respiration in learners from urban and semi-urban environments.

7.2. EVALUATION AND TESTING OF SOLUTION IN PRACTICE

7.2.1. Introduction

This part of the study investigated the use of an educational computer game to overcome misconceptions in photosynthesis and respirations. Research carried out by Adams (1998) identifies a number of misconceptions related to photosynthesis and respiration and informed the design of the educational adventure game *Zadarh* where specific problems were integrated into the game to specifically address these identified misconceptions. It is argued that through the play of *Zadarh,* authentic tasks encapsulated in puzzles such as the filling of the player's oxygen cylinder (for an air supply) and the filling of a carbon dioxide cylinder (used to extinguish fire) will allow players to challenge their misconceptions and re-evaluate their beliefs and knowledge related to photosynthesis and respiration.

7.2.2. Misconceptions

One of the important learning deficiencies relates to the concept of misconceptions. Most students, at all educational levels, enter the classroom with mental models of phenomena that may be at variance with accepted scientific models of those same phenomena (Michael**,** 1998). Their understanding of many physiological phenomena is often seriously flawed (Michael, 2002). It is argued that children can develop parallel but mutually inconsistent explanations of scientific concepts — one for use in school and one for use in the "real world" (Trowbridge and Mintzes, 1985). Educators have used a variety of terms to describe the situation in which students' ideas about a concept differ from those of scientists (Blosser, 1987). Some tend to call them "preconceptions," "commonsense understandings," "alternative frameworks", "children's science," "experience-based" and "misconceptions" (Wandersee *et al.,* 1994; Michael, 1998; Michael, 2002). The misconceptions usually have a basis in everyday experience and that they often reflect imaginative attempts to make sense of what people have observed and been taught (Wandersee *et al.,* 1994). Misconceptions held by children proved difficult to change, even with the assistance from specially developed instructional materials (Roth, 1985). Blosser (1987) asserts that the term "misconception" indicate an obvious connotation of a wrong idea or an incorrectly assimilated formal model or theory. Misconceptions serve the needs of the persons who hold them and that erroneous ideas may come from strong word association, confusion, conflict, or lack of knowledge (Fisher, 1985).

Children come to school already holding beliefs about how things happen, and do have certain expectations — based on their past experiences — which enable them to predict future events. Children hold ideas that were developed before and during their early school years, and these ideas may be compounded by the teacher and/or the textbook. There is a wrong assumption among science teachers that pupils do not have prior experiences relative to the topic being studied (Blosser, 1987); because teachers and students may fail to share the meaning of the terms used when asking questions, there is a need for teachers to consider the extent to which misconceptions may be due to language difficulties.

The situation with misconception is not foreign to South Africa as there are serious educational and pedagogical problems because of the socio-economic disparities between the different categories of learners and the people of the country. The study carried out by Adams (1998) uncovered the deep-rootedness of some of these misconceptions. This study tried to ascertain if the problem could be resolved by the usage of computer games such as *Zadarh*.

7.2.2.1 Characteristics of Misconceptions

According to Fisher (1985) misconceptions share the following characteristics: (i) They are at variance with conceptions held by experts in the field; (ii) A single misconception, or a small number of misconceptions, tends to be pervasive – shared by many different individuals; (iii) Misconceptions are highly resistant to change or alteration, at least by traditional teaching methods; (iv) They sometimes involve alternative belief systems comprised of logically linked sets of propositions that are used by students in systematic ways; and (v) Some have historical precedence: that is, some erroneous ideas put forth by students today mirror ideas espoused by early leaders in the field. For example, Hershey (2004) classifies misconceptions into five categories: (i) Oversimplifications – of concepts, particularly at the pre-tertiary level; (ii) Overgeneralisations – teaching publications sometimes state that all plants are photosynthetic, although they constitute less than 1% of plant species; (iii) Obsolete concepts and terms – plants once thought to be saprophytes, such as Indian pipe (Monotropa uniflora), are now known to be indirectly parasitic on trees; (iv) Misidentifications – a celery stalk is often misidentified as a stem; and (v) Flawed research – the most difficult misconceptions for teachers to catch are those caused by flawed research.

7.2.2.2. Types of misconceptions

The National Academy of Sciences (1997) classifies misconceptions as: (i) Preconceived notions that are popular conceptions rooted in everyday experiences; (ii) Non-scientific beliefs

include views learned by students from sources other than scientific education, such as religious or mythical teachings; (iii) Conceptual misunderstandings arising when students are taught scientific information in a way that does not provoke them to confront paradoxes and conflicts resulting from their own preconceived notions and non-scientific beliefs; (iv) Vernacular misconceptions arising from the use of words that mean one thing in everyday life and another in a scientific context; and (v) Factual misconceptions, which are falsities often learned at an early age and retained unchallenged into adulthood. The problem with misconceptions is that they are often quite persistent, and they seriously interfere with the students' ability to learn physiology (Michael, 2002).

The term "misconception'' will be used here to describe incorrect and unscientific models of phenomena. It is worth noting that much research on this topic already exists, and Waheed and Lucas (1992) say that the previously undertaken research has not explored students' understanding of the relationships between anatomical, physiological, biochemical and ecological aspects of the process. Adams (1998) found that students who had played *Zadarh*, an educational adventure game, demonstrated a much clearer understanding of the complementary relationship between photosynthesis and respiration, than did students who have not played the game. Therefore, this part of the study investigates the use of *Zadarh* to overcome misconceptions related to photosynthesis and respiration in learners from urban and semi-urban environments.

7.2.3. Participating Schools

The study is the continuation to the base study covered in the previous study. Participants for this study came from two community high schools, Qhakaza High School (Qhakaza, Grade 11 students), and Buhlebemfundo Secondary School (Buhlebemfundo, Grade 12 students) and from the University of Zululand (UniZulu, first year Business Information Systems students). Having discovered from the previous section that the community schools had yielded similar result Tholokuhle was dropped from further participation in the study as the results of the remaining schools will be representative of all other community schools. Again, UKZN was also dropped having realised that its learners' skills proficiency was also high enough to yield limited results. Thus, the number of learners who took part in the study and the administered post-test were 19 from Qhakaza, 45 came from Buhlebemfundo and UniZulu had seven. Buhlebemfundo is located in Kwa-Dabeka township about 25km from Durban, while Qhakaza and UniZulu are situated in Kwa-Dlangezwa township about 160km north of Durban. The tests were carried out between August 2003 and May 2005.

7.2.4. Assumptions on Participating Students

Buhlebemfundo did not provide computer literacy courses while Qhakaza and UniZulu did. Therefore, based on this information and before students embarked on the research a number of assumptions were made:

(a) *Computer literacy skills.* It was assumed that Buhlebemfundo learners without computer skills would struggle with playing the game, particularly the use of the mouse. On the other hand, there was an assumption that Qhakaza learners and University of Zululand would have fewer problems with the use of mouse, switching on and off the computers, using keyboards and typing. Also, Qhakaza and UniZulu learners would be familiar with the Windows operating system.

(b) *Communication skills*. Regarding English proficiency, it was assumed that learners from the three schools would be at the same level of literacy because of the literacy and communication results obtained from the visualisation, numeric, logic, and communication skills tests which indicated no significant difference between the 3 groups. With respect to the content of the game, it was anticipated that most learners would at first struggle with the scientific content of the study as most of them were not from the science streams.

7.2.5. Computer Literary of Participating Students

No computer Local Area Network (LAN) was available at Buhlebemfundo and therefore, the 63 learners volunteered were bussed to the UKZN. However, only 45 students participated in the post-test. The majority of these learners had never used computers before; 42 indicated that they had never used computers before while 3 stated that they had access to computer (1 at home and 2 at previous schools). The benefit of learning some basic computer skills was the driving force behind these learners volunteering to participate in this study. After playing the game participants were allowed to surf the Internet and learn more about using computers. Thus, most of these learners found working in a computer LAN both exciting and intimidating. Each Buhlebemfundo player spent two hours per session for ten sessions working on the computer between August and October 2003.

On the other hand, Qhakaza and UniZulu learners attended their sessions at UniZulu where a LAN was made available for the project. Twenty four learners from Qhakaza and 10 from UniZulu participated in the project. Although students from Qhakaza were studying computer

literacy at school, 20 claimed that they had never used computers before and only one had access to one at home. Qhakaza learners had access to the LAN in the afternoons and participated in 10 sessions of two hours each with a few learners staying on for about an hour before the LAN could be closed. The LAN was available to the UniZulu students at all times during the day provided it was not in official university use, however, many could not use this time effectively as it clashed with their daily time-table. The study took place over a period of successive 10 weeks, punctuated only by the schools and public holidays. Although high school learners did not have any computer skills, UniZulu students were computer literate.

The first session was spent introducing learners to the computer and the game environment. For example, some of the things taught included computer components, desktop and its items, opening folders and files and introducing *Zadarh*.

7.2.6. Materials and Tools

In this study, the same three-tiered questionnaire (Annex 2 and 3) developed by Adams (1998), was used by the researcher to evaluate misconceptions help by participants after game play. In the construction of the questionnaire Adams considered instruments developed by Haslam and Treagust (1987) and Amir and Tamir (1994) and other findings, interviews and open-ended pencil-and-paper tests. According to Adams these researchers used questionnaires that included the use of propositional statements and concept maps. All the propositional statements were addressed in the questionnaire that consisted of thirteen three-tiered multiple-choice questions. A subject expert from the Biology Department of the University of KwaZulu-Natal verified the accuracy of the questions. The first tier of each question was a factual multiple choice (MC) question, probing a concept within one of the topics, or the relationship between the two topics. Tier two, also in MC format, probed the students' understanding by asking them to supply a reason for their answer to the tier one question. In the third tier students were asked to rate the confidence they had in their answer. Confidence ratings ranged from 1 to 4, representing the choices 'not at all confident', 'somewhat confident' 'confident' and 'very confident'. Most learners played the game between 18 - 20 hours.

7.2.7. Procedures

In order to evaluating the effectiveness of the *Zadarh* to address misconceptions related to photosynthesis and respiration a number of data collections strategies were utilised and these include usage of questionnaire, observations and written tests. The first method used was to observe learners while playing *Zadarh*. Secondly, a few learners were asked for their opinion

about the game. The third was to administer a paper-and-pencil post-test. For the first task learners played *Zadarh* individually. As most learners did not have any computer skills, they found it quite difficult to move and explore 3-dimensional space environment. Lack of prior experience in the use of the computer mouse made exploration difficult.

7.2.8. *Zadarh* Environment

Zadarh is a three-dimensional adventure game which uses a 'click' and 'drag' or 'click' and 'grab' mechanisms to play. According to Adams (1998) one aspect of this game is to teach the concept of simultaneous and complementary relationship between photosynthesis and respiration. Navigating the game environment was based on moving from predefined node to node via a choice of 1 of 4 cardinal compass directions of east, west, north and south. It was observed that most learners found this navigation difficult. Arrows were used to indicate these cardinal compass points and the direction of movement available to the player (Fig. 7.1, a-d), to indicate areas of interaction (Fig. 7.1e) and also a default cursor (Fig. 7.1f). The interaction arrow was used for moving, picking up, opening and closing of objects and for performing other manipulations.

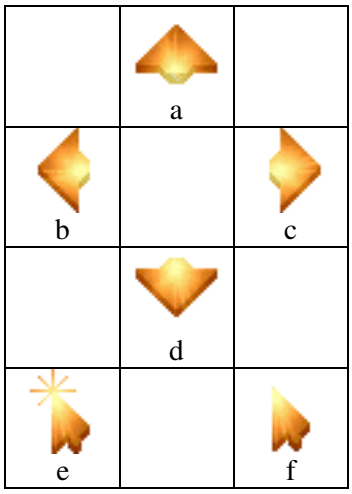

Figure 7.1: Different arrows used in the game *Zadarh*.

Through exploration players discovered that items, or objects, could be collected into an inventory as they navigated the play areas or solved puzzles. A close-up view of collected objects is accessed by right-clicking an object in the inventory. Discovering such game conventions early on in the game appears to stimulate further exploration of the game environment.

Learners were asked to play *Zadarh* after the objectives of the study were explained. At the start of the game players were told that their oxygen levels were low and therefore, they need to refill the oxygen cylinder. Once playing the game had commenced problems were rapidly discovered. For example, learners lacked skills to move in a 3-dimensional environment. Most learners did not have any prior exposure to the 3D environment, lacked the computer skills, and therefore found exploring the game quite difficult. Navigating the game using the four cardinal compass directions was at first a serious problem for most learners, as they could not tell the directions, although such movements were made obvious through fading and scrolling of images in the game environment. Below are some examples of puzzles learners encountered while playing the game.

(i) ***Burning storeroom***

The game commenced with a storeroom burning (Fig. 7.2) and there was already insufficient oxygen in the room. Hence, there was an urgent need to extinguish the fire to conserve oxygen. Players could not extinguish this fire until they have solved other puzzles utilised in the game, such as filling a cylinder with carbon dioxide used later in extinguishing the fire.

Figure 7.2: The burning storeroom at the start of the game.

(ii) ***Photosynthesis and respiration linguistic puzzle***

By selecting the right spots on this flower puzzle, statements about both photosynthesis and respiration are displayed (Fig. 7.3). Here, learners need to discover that respiration occurs both in the light and dark, while photosynthesis occurs only in the light.

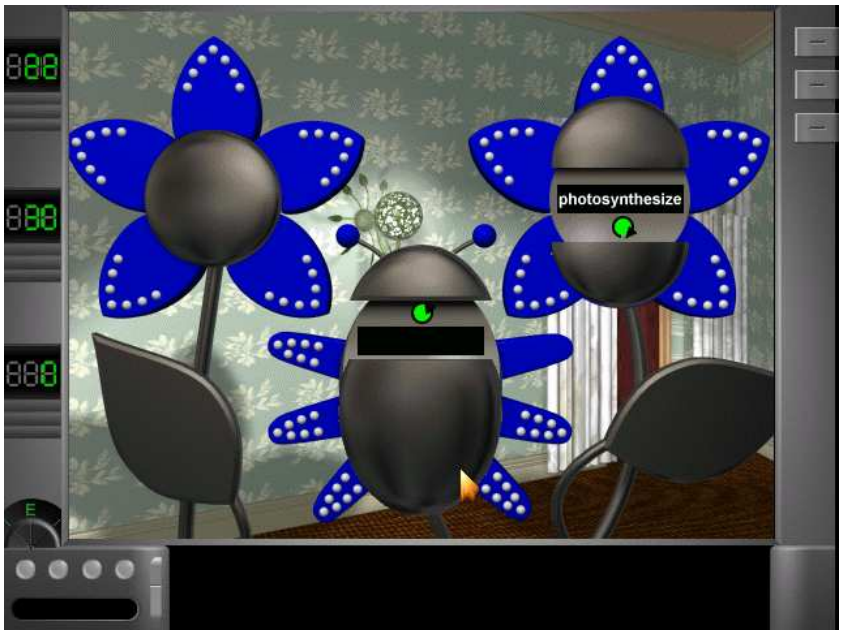

Figure 7.3: The linguistic puzzle which students use to create sentences about photosynthesis and respiration.

(iii) The musical puzzle

The music puzzle (Fig. 7.4) illustrates to players that the photosynthetic and respiratory processes are complementary.

Figure 7.4: The musical puzzle showing musical notation to be played on the piano keyboard.

(iv) ***Opening the safe***

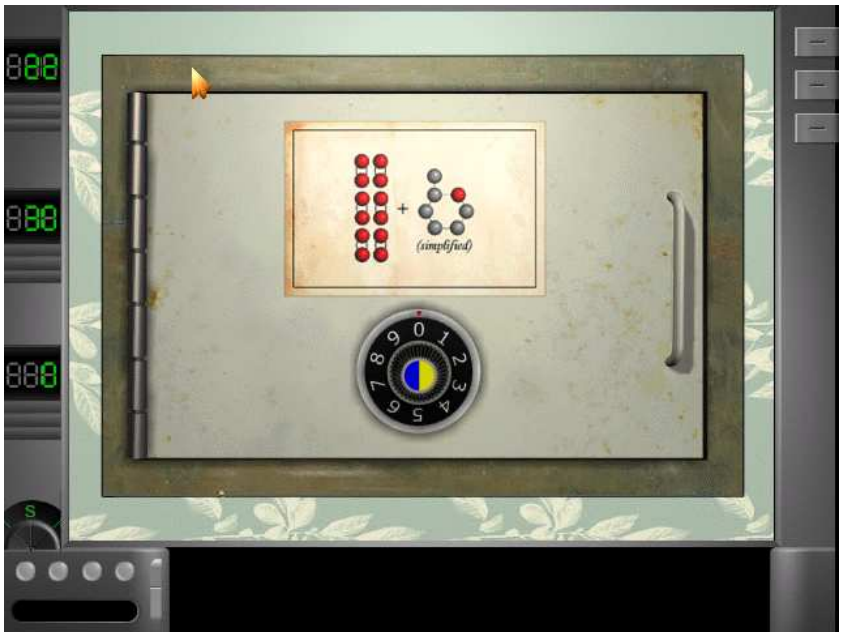

Figure 7.5: The safe puzzle contains token required to solve another puzzle.

The safe puzzle (Fig. 5) uses the molecular mass of the components to open the safe where token to solve other puzzles are stored.

(v) ***The gas panel***

In this room (Fig 7.6) students can produce carbon dioxide by altering gas and light supplies through the reaction chamber in order to fill the air tank with carbon dioxide**.**

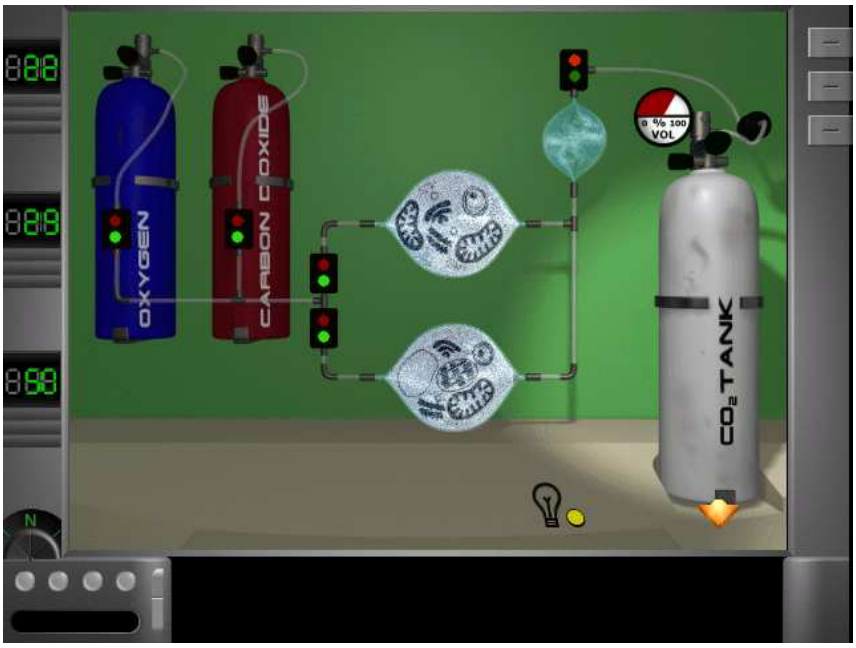

Figure 7.6: Illustrates the reaction puzzle used to produce carbon dioxide gas.

(vi) ***The antidote***

Figure 7.7: The remainder of carbon dioxide is used to retrieve the antidote found in the storeroom.

After extinguishing the burning fire with the produced carbon dioxide (Fig 7.6) the player gain access to the storeroom and using a key and some to carbon dioxide gas retrieves the antidote (Fig. 7.7).

7.2.9. Observations

Students became quite joyous as they played the game and used information they acquired from discovering game objects and solving puzzles. Many times learners would jump up with joy when they saw a door opening, fire being extinguished, money safe opening, etc. One student who was frustrated at one point because she could not open one of the doors jumped up with excitement and exclaimed, "Wow, I am so happy. I am so relieved, oh my God" when she was finally able to open the door.

There was a huge motivational difference between those learners who were discovering things individually and those who needed help. Learners who solved puzzles without help seemed to enjoy the game more than those who required hints from others to solve the puzzles. Those progressing appeared to be more logical in their approach to solving puzzles and other problems. Those who were receiving help having a short spell of interest in the game as they were spending more time idling about not knowing what to do. They would show huge interest after discovering something but each struggle made them lose interest. They would start

fiddling with the computer and start watching those sitting next to them to see how they were coping with the game. Therefore, discovering objects kept the motivation of learners high.

The biggest problem with playing *Zadarh* was the requirement to read information in either the books or charts which the students appeared not to do. For example, wall charts providing crucial information were taken for granted. When the game begins, players are informed about the objectives of their mission via scrolling text. However, most learners became frustrated, as they did not know what was expected of them because they did not read the introductory information. From time to time, the researcher would ask learners to restart the game and read everything until they knew what their mission was. However, learners quickly discovered that it was important to read all the information presented as such information helped them solve puzzles but felt that reading wasted their time gaining access to the next game level. After playing *Zadarh* for a couple of times almost all students started playing without reading and appeared to be playing from memory.

Many computer-related problems were also encountered once game-play had started. Most learners from high schools had little practical knowledge of computers. There were some players from Qhakaza who had never used a computer mouse before and therefore, did not understand the terms single- and double-click. This lack of hands-on experience frustrated most learners. Therefore, to solve this problem it was suggested to Buhlebemfundo and Qhakaza learners that they play the game of solitaire, found as part of the XP operating system, in order to try to familiarise themselves with mouse movements, single- or double-mouse clicks, and dragging of the cards on-screen. Once the majority of learners were comfortable with moving and clicking the mouse they were urged to start playing *Zadarh*.

Soon after the commencement of game-play it became obvious that there was competition between the learners to see who would find more objects and who would finish the game first. Such competitions created many problems as some students were forced to ask for assistance without trying to solve the problems themselves. Those students who thought they were not winning asked questions such as “when am I considered to have won?” or “can I skip this section and go to the next level which looks like it is more interesting?”

7.2.10. Questionnaire Results

In an attempt to answer the question whether playing of games can assist learners to overcome misconceptions, students from three schools (Buhlebemfundo, Qhakaza and UniZulu) played

Zadarh for 18 to 20 hours and then answered the questionnaire previously used by Adams (1998) to identify the associated misconceptions where each question consisted of 3 tiers: (i) A factual MC question; (ii) A MC question giving a reason for the answer; and (iii) A confidence question (the confidence varied from 1 to 4 where 1 represented the lowest and 4 the highest confidence level). In order to interpreting the confidence mean ratios between 1 to 2 described a lack or low confidence, a medium confidence ranged between 2 to 3 and a score of 3 to 4 indicated a high confidence. For performance, percentages above 70% were considered excellent, 60% to 69% good, 40% to 59% medium and below 40% as poor.

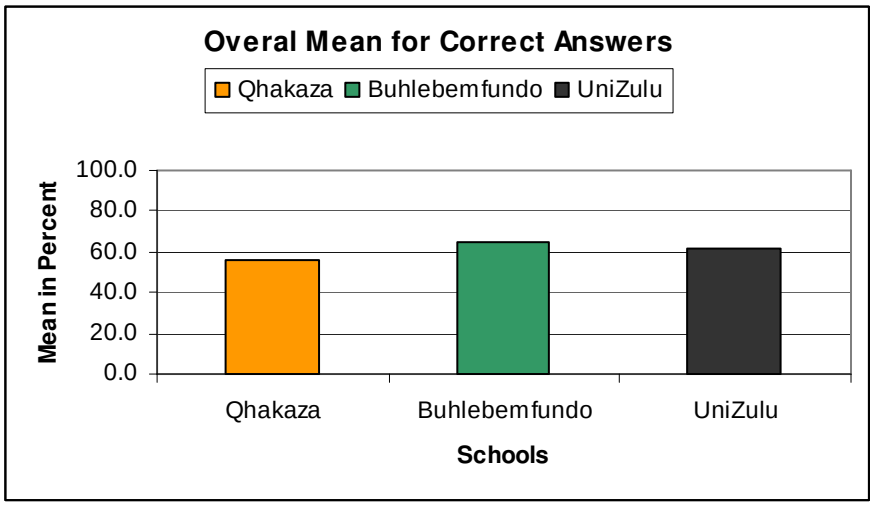

Figure 7.8: Mean scores (tier 1) for participants from three schools.

Participants from Qhakaza attained the mean score of 57.9%, from Buhlebemfundo 63.4% and from UniZulu 62.6% for the factual MC questions (Fig. 7.8) suggesting that the majority of learners had a fairly good general understanding of the processes associated with photosynthesis and respiration.

However, most learners could not substantiate their answers with correct reasons (tier 2 MC questions) for there answers (Fig. 7.9) and this meant that their comprehension of the processes involved and the products of those processes were lacking or in other words, misconceptions still existed. With a mean score of 31.9%, Buhlebemfundo outperformed Qhakaza and UniZulu who scored 28.4%and 30.8% respectively.

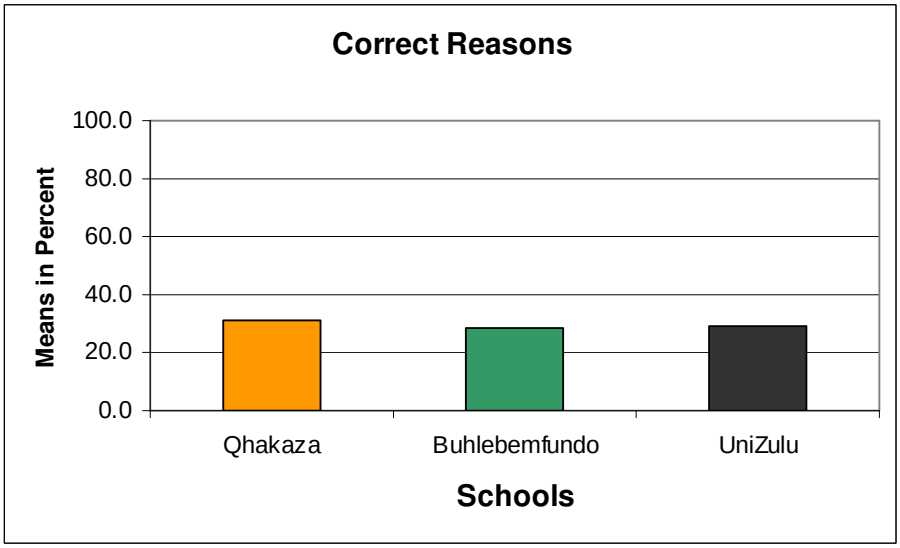

Figure 7.9: Mean scores (tier 2) for participants from three schools

The following section analyses the questions in detail and compare the findings to those of Adams (1998) (See Annex 2 for questions). Results are given in Fig. 7.10. which highlight the correct answers and the correct reasons. Mean confidences are given in tables associated with each question where the correct answers are indicated with asterisk (*).

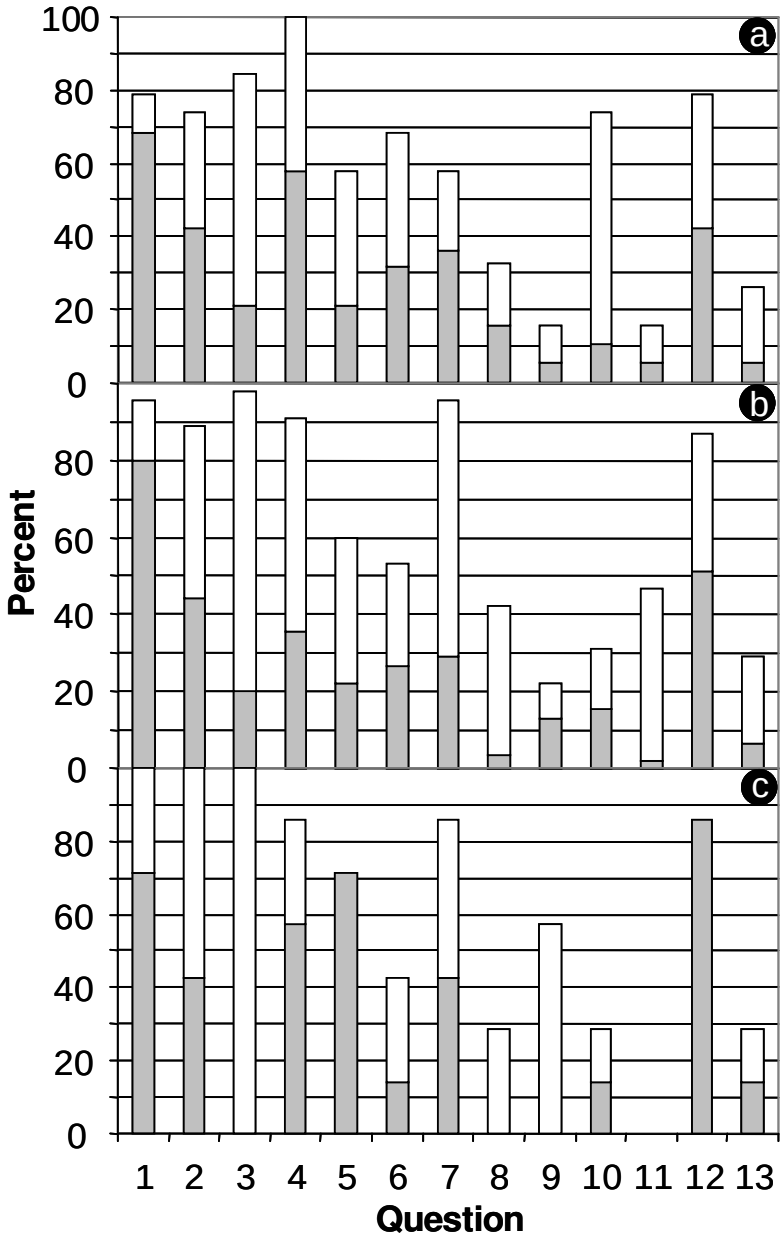

Figure 7.10: Percent of correct answers given by participants from (a) Qhakaza (b) Buhlebemfundo and (c) UniZulu. The shaded represents the percentage that identified the correct reasons.

Question 1

Question 1 asked students to name the process by which plants produce 'food'. Most learners correctly selected photosynthesis (Qhakaza = 78.9%, Buhlebemfundo = 95.6% and UniZulu = 100%) (Fig. 7.10). These results are similar to those of Adams (1988) who showed that after game-play learners had a better understand of the processes by which plants make 'food'. This contradicts earlier findings by Hazel and Prosser (1994) who found that learners' intuitive definition of plant 'food' was not compatible to the scientific view as they mostly thought of plant food as water, minerals nutrients and carbon dioxide taken in through the roots and leaves.

After playing *Zadarh* many players (Qhakaza = 68.4%, Buhlebemfundo = 80% and UniZulu = 71.4%) correctly identifying the process of conversion of light energy to chemical energy (tier 2 question); the overall mean confidence for their answer was high at 3.2 with participants from Qhakaza at 3.31, Buhlebemfundo at 3.2 and UniZulu at 3.09 (Table 7.1).

Table 1: Percentage of students selecting two-tiered options for question one.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	0	10.5	0	68.4*		78.9	3.31
Buhlebemfundo Grade 12	45	A B C D	6.7	4.4	2.2	80*		95.6	3.2
UniZulu First Year (BIS)	7	A B C D	14.3	0	14.3	71.4*		100	3.09

Correct answers are indicated with asterisk (*)

Question 2

Question 2 deals directly with the relationship between photosynthesis and respiration. Contrary to Adams (1998) findings where the highest result of 71.2% was obtained by Techikon new intakes, 48.1% by Cell Biology new intakes and 58.8% by seniors, most participants in this study chose the correct answer (Qhakaza = 89.5%, Buhlebemfundo = 88.9% and UniZulu = 100%) suggesting that learners who played *Zadarh* understood that the relationships were not opposite but complementary. However, less than half of those who gave the right answer provided the wrong reasons for their choice. They wrongly thought that photosynthesis is a constructive process that may lead to an increase in mass of the plant, whereas respiration leads to a weight loss by plants (Qhakaza = 21.1%, Buhlebemfundo = 40% and UniZulu = 42. 9%). However, learners participating in Adams performed better as 52.7% of Cell Biology new intakes, 44.4% of first years, 66.1% of Techikon new intakes, and 55.9% of seniors understood the processes. A high number of learners (Qhakaza = 57.9%, Buhlebemfundo = 44.4% and UniZulu = 42. 9%) thought that the products of photosynthesis are used as reactants in respiration, a common misconception. The high overall mean confidence of 3.41 (Qhakaza = 3.2, Buhlebemfundo =3.56 and UniZulu = 3.47) supports the conclusion that most learners do not understand the relationship between photosynthesis and respiration (Table 2).

Questions 3 to 6 deal indirectly with the relationship between photosynthesis and respiration, probing students understanding of the products and reactants of these processes, and when such processes occur.

Table 2: Percentage of students selecting two-tiered options for question two.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	0	10.5	21.1	57.9*		89.5	3.2
Buhlebemfundo Grade 12	45	A B C D	2.2	2.2	40	44.4*		88.8	3.56
UniZulu First Year (BIS)	7	A B C D	0	14.3	42. 9	42.9*		100	3.47

Correct answers are indicated with asterisk (*)

Question 3

Table 3: Percentage of students selecting two-tiered options for question three.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	15.8	21.1	21.1*	23.3	-	84.2	3.25
Buhlebemfundo Grade 12	45	A B C D	0	11.1	20*	68.4	-	97.8	2.2
UniZulu First Year (BIS)	7	A B C D	0	85.7	0	14.3		100	2.65

Correct answers are indicated with asterisk (*)

Question 3 asked which gas is released in large amounts in the presence of sunlight. Just like in Adams' study where results ranged between 89.9% and 97.1% most students correctly chose oxygen (Qhakaza = 84.2%, Buhlebemfundo = 97.8% and UniZulu = 100%). However, their understanding of the process was somewhat confused in that a small number (Qhakaza = 68.4%, Buhlebemfundo = 20% and UniZulu = 0%) understood that more oxygen than is needed for

respiration and other processes is produced by the plant during photosynthesis, and therefore, the excess gas is given off. Again, this compares with Adams' results where fewer students grasped this process (12.2% of Cell Biology new intakes, 15.2% of first years, 13.1% of Techikon new intakes, and 26.5% of seniors). The majority of Buhlebemfundo (66.7%) and 23.3% of Qhakaza thought that oxygen was a by-product of photosynthesis while almost all of UniZulu (85.7%) answered incorrectly by asserting that plants do not respire during the day. These misconception are illustrated by high mean confidence of 3.25 from Qhakaza learners and the medium mean confidences from Buhlebemfundo (2.2) and UniZulu (2.65) learners (Table 3).

Question 4

Question 4 asked which gas is absorbed in largest amounts in the presence of sunlight. The results are similar to those of Adams (95.1% of Techikon new intakes, 94.6% of Cell Biology new intakes, 90.1% of first years, and 97.1% of seniors) with most students giving the correct answer (carbon dioxide), (Qhakaza = 100%, Buhlebemfundo = 91.1% and UniZulu = 85.7%). However, few comprehended that this is because photosynthesis is dependent on light (Qhakaza = 57.9%, Buhlebemfundo = 35.6% and UniZulu = 57.2%). From Adams' study, more understood these relations (45.9% of Techikon new intakes, 61.2% of Cell Biology new intakes, 67.9% of first years, and 70.6% of seniors). Most of Buhlebemfundo (37.8%) believed that photosynthesis is a continuous process that takes place day and night. Even though just about half of the students got the answers correct the overall high mean confidence of 3.08 (Qhakaza = 3.25, Buhlebemfundo = 2.77 and UniZulu = 3.19) again illustrate the deep-rootedness of the misconceptions (Table 4).

Table 4: Percentage of students selecting two-tiered options for question four.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	5.3	57.9*	21.1	15.8		100	3.25
Buhlebemfundo Grade 12	45	A B C D	11.1	35.6*	37.8	6.7		91.1	2.77
UniZulu First Year (BIS)	7	A B C D	28.6	57.4*	0	0		85.7	3.19

Correct answers are indicated with asterisk (*)

Question 5

Question 5 asked which gas is absorbed in largest amounts in the dark. Oxygen was correctly selected by 57.9% of Qhakaza, 60% of Buhlebemfundo and 71.4% of UniZulu participants. These results are slightly lower than those found by Adams (64.4% of Techikon new intakes, 64.2% of Cell Biology new intakes, 80.5% of first years, and 75.8% of seniors). Few learners, with the exception of 71.4% of UniZulu, were aware that oxygen absorbed is used in respiration (Qhakaza = 21.1%, Buhlebemfundo = 22.2 %). Again Learners in Adams' study did better with 22% of Techikon new intakes, 39.2% of Cell Biology new intakes, 48.1% of first years, and 45.5% of seniors all aware that respiration process is continuous. The overall mean confidence was in the mid range at 2.81 but this again showed the deep-rootedness of these misconceptions; individual mean confidences were 2.37 for Qhakaza, 2.79 for Buhlebemfundo and 3.27 for UniZulu learners (Table 5).

Table 5: Percentage of students selecting two-tiered options for question five.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	15.8	10.5	21.1*	10.5		57.9	2.37
Buhlebemfundo Grade 12	45	A B C D	4.4	20	22.2*	13.3		60	2.79
UniZulu First Year (BIS)	7	A B C D	0	0	71.4*	0		71.4	3.27

Correct answers are indicated with asterisk (*)

Question 6

Question 6 asked which gas is released in largest amounts in the absence of light. Slightly over half of students correctly selected carbon dioxide (Qhakaza = 68.4%, Buhlebemfundo = 53.3% and UniZulu = 42.9%). This performance was again lower than in the Adams study (73.3% of Techikon new intakes, 57% of Cell Biology new intakes, 88% of first years, and 76.5% of seniors). Again about half of those who had the right answer understood that respiration is a process that takes place all the time (Qhakaza = 31.6%, Buhlebemfundo = 26.7% and UniZulu = 14.3%). Learners in Adams' study better understood when respiration happens (51.7% of Techikon new intakes, 46.3% of Cell Biology new intakes, 68.0% of first years, and 58.8% of seniors). The mean confidence expressed by students was high at 3.12 with Buhlebemfundo

learners expressing the least confidence (2.98), UniZulu learners scored 3.04 and those from Qhakaza had the highest score (3.34) (Table 6). Again, the poor performance and the high confidence levels demonstrate a misconception.

Table 6: Percentage of students selecting two-tiered options for question six.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	31.6*	21.1	15.8	0		68.4	3.34
Buhlebemfundo Grade 12	45	A B C D	26.7*	4.4	22.2			53.3	2.98
UniZulu First Year (BIS)	7	A B C D	14.3*	0	28.6	0		42.9	3.04

Correct answers are indicated with asterisk (*)

Responses to questions 3 to 6 are similar to those previously reported by Adams (1998) and indicate that students have a poor grasp of the complementary relationship between photosynthesis and respiration and the times at which these processes occur.

Questions 7 to 9 deal with the relationship between the light and dark phases of photosynthesis and the performance demonstrates a lack of understanding of the different processes involved.

Question 7

Question 7 asked when the light phase of photosynthesis occurred. The majority of participants knew that photosynthesis occurs only in the presence of light (Qhakaza = 75.9%, Buhlebemfundo = 95.6% and UniZulu = 85.7%). This performance was again lower than in the Adams study where 90% of Techikon new intakes, 87.6% of Cell Biology new intakes, 94.8% of first years, and 97.1% of seniors understood when photosynthesis took place. The role of light in this process was less clearly understood as illustrated by less than 50% of correct answers (36.3% of Qhakaza, 28.9% of Buhlebemfundo and 42.9% from UniZulu) who were aware that the light phase involves electron transport, which only takes place when sunlight excites chlorophyll molecules, causing the molecules to give up electrons. However, an equal number of participants wrongly believed that the light phase involves the uptake of carbon dioxide in the dark (Qhakaza = 25.3%, Buhlebemfundo = 60% and UniZulu = 42.9%). These

results were worse than those found by Adams (1998) where over 50% understood the processes involved (58.3% of Techikon new intakes, 57% of Cell Biology new intakes, 68.8% of first years, and 82.4% of seniors). Although most learners selected the wrong reason for their answer they were fairly confident in their answers (Qhakaza =3.1, Buhlebemfundo = 2.4 and UniZulu = 2.51) again illustrating a deep-seated misconception (Table 7).

Table 7: Percentage of students selecting two-tiered options for question seven.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	36.3*	10.5	25.3	5.3		75.9	3.1
Buhlebemfundo Grade 12	45	A B C D	28.9*	2.2	60	4.4		95.6	2.4
UniZulu First Year (BIS)	7	A B C D	42.9*	0	42.9	0		85.7	2.51

Correct answers are indicated with asterisk (*)

Question 8

Table 8: Percentage of students selecting two-tiered options for question eight.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	10.5	5.3	0	15.8*		31.6	2.8
Buhlebemfundo Grade 12	45	A B C D	6.7		31.1	4.4*		42.2*	2.66
UniZulu First Year (BIS)	7	A B C D	14.3	0	14.3	0*		28.6	2.91

Correct answers are indicated with asterisk (*)

Question 8 asked when the dark phase of photosynthesis occurs. This question was badly answered by all schools with performances mainly below 50%. Adams (50.8% of Techikon new intakes, 31.1% of Cell Biology new intakes, 45.5% of first years, and 14.7% of seniors)

obtained similar results. The most common misconception expressed was that the dark phase takes place only in the dark (Qhakaza = 31.6%, Buhlebemfundo = 42.2 % and UniZulu = 28.6%). Few learners (Qhakaza = 15.8%, Buhlebemfundo = 4.4% and UniZulu = 0%) knew that the dark phase is simply light independent, and thus takes place continuously, in the presence or absence of light. Learners in Adams' study performed better with 39.3% of Techikon new intakes, 55.7% of Cell Biology new intakes, 45.1% of first years, and 76.5% of seniors understanding the definition of the dark phase. Again, these serious misconceptions were revealed by the fact that even though wrong reasons were given the overall mean confidence in their answers was medium at 2.78. It was lowest for Buhlebemfundo participants at 2.66, Qhakaza learners obtained a mean score of 2.8 and those from UniZulu had the highest with 2.91 even though none provided the right reason for their answer (Table 8).

Questions 9

Table 9: Percentage of students selecting two-tiered options for question nine.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	5.3*	0	10.6	0		15.8	1.57
Buhlebemfundo Grade 12	45	A B C D	13.3*		6.7	2.2		22.2	2.32
UniZulu First Year (BIS)	7	A B C D	0*	57.4	0	0		57.4	3.1

Correct answers are indicated with asterisk (*)

Question 9 explicitly asked about the relationship of the light and dark phases of photosynthesis. The performance was poor with few students able to identify these as complementary processes (Qhakaza = 15.8%, Buhlebemfundo = 22.2% and UniZulu = 57.4%) unlike in Adams' study where 68.9% of Techikon new intakes, 80.8% of Cell Biology new intakes, 75.9% of first years, and 85.3% of seniors managed. Those that could identify products and functions of each phase comprised 5.3% of Qhakaza, 13.3% of Buhlebemfundo, and none from UniZulu participants. More learners from Adams' study could identify these products and functions (41% of Techikon new intakes, 49.2% of Cell Biology new intakes, 43.8% of first years, and 50% of seniors). However, low mean confidences from the three school of 2.33 showed that students

did not understand the relationships. Qhakaza participants had the lowest mean at 1.57, which indicates a lack of confidence in their choice of answer while those from Buhlebemfundo received a medium value with a confidence level of 2.32. UniZulu participants performed poorly but were confident (3.1) in their answer again illustrating the serious misconceptions held by these learners (Table 9).

Responses to questions 7 to 9 were similar to those previously reported by Adams (1998). The same misconceptions were revealed after playing *Zadarh* as learners were not clear about the different processes that occur in the light and dark phases of photosynthesis, and how these processes are related.

Question 10

Table 10: Percentage of students selecting two-tiered options for question ten.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	47.3	10.5*	15.8	0		73.7	1.72
Buhlebemfundo Grade 12	45	A B C D	11.1	15.6*	4.4	0	0	31.1	2.08
UniZulu First Year (BIS)	7	A B C D	14.3	14.3*	0	0		28.6	2.14

Correct answers are indicated with asterisk (*)

Question 10 asked students to identify the light compensation point on a figure of a light response curve. With the exception of many of the learners from Qhakaza (73.3%), few from other schools could identify the light compensation point (Buhlebemfundo = 31.1% and UniZulu = 28.6%). This was in contrast with Adams' where results were good (61.7% of Techikon new intakes, 64.9% of Cell Biology new intakes, 72.2% of first years, and 94.1% of seniors) Fewer students (Qhakaza = 10.5%, Buhlebemfundo = 15.6% and UniZulu = 14.3%) could interpret its significance, that is, at this light intensity the rate of photosynthesis equals the rate of respiration. The results were better in the study by Adams (26.7% of Techikon new intakes, 31.6% of Cell Biology new intakes, 33.3% of first years, and 76.5% of seniors). Most Qhakaza learners (47.3%) thought that at this point there is more light being produced leading to more photosynthesis taking place. The overall mean confidence was low at 1.98 (Qhakaza =

1.57, Buhlebemfundo = 2.08 and UniZulu = 2.14) (Table 10). Therefore, most participants did not understand this relationship.

Question 11

In question 11, student understanding of limiting factors was investigated. Once again, a light response curve was presented and students were required to identify the point at which the rate of photosynthesis became constant. Fewer students could identify this point (Qhakaza = 15.8%, Buhlebemfundo = 46.7% and UniZulu = 0%) than in Adams study (67.2% of Techikon new intakes, 72.1% of Cell Biology new intakes, 77.3% of first years, and 73.5% of seniors). The second tier questions asked what caused the levelling off of the curve. Only 5.3% of Qhakaza, 2.2% of Buhlebemfundo, none of the UniZulu participants knew that something other than light was limiting photosynthesis at this point compared to 9.8% of Techikon new intakes, 19.8% of Cell Biology new intakes, 30.7% of first years, and 64.7% of seniors from Adams' study. Many of Buhlebemfundo's learners (37.8%) wrongly thought that at this point, there is too much light and the plant is no longer photosynthesising. The overall mean confidence was medium at 2.33 with those from Qhakaza scoring 1.57, from Buhlebemfundo scoring 2.28 and those from UniZulu scoring 3.14 where none of them had the correct reasons for their answer (Table 11).

Table 11: Percentage of students selecting two-tiered options for question eleven.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	5.3	5.3*	0	5.3		15.8	1.57
Buhlebemfundo Grade 12	45	A B C D	6.7	2.2*	37.8	2.2		46.7	2.28
UniZulu First Year (BIS)	7	A B C D	0	0*	0	0		0	3.14

Correct answers are indicated with asterisk (*)

Questions 10 and 11, which required students to interpret a light response curve, were poorly answered. This differs from the results of Adams (1998) who found that younger learners did not perform well in this question but older participants provided better answers. In this study all students who played *Zadarh* struggled to identifying the significance of different points on the curve.

Question 12

Question 12 asked the students to identify the equation representing the net reaction of photosynthesis. Similar to Adams (67.2% of Techikon new intakes, 72.1% of Cell Biology new intakes, 79.2% of first years, and 90.9% of seniors) a large proportion could identify this equation correctly (Qhakaza = 78.9%, Buhlebemfundo = 86.7% and UniZulu = 85.7%). Fewer could interpret which were products and reactants (42.1% of Qhakaza, Buhlebemfundo = 51.1% and UniZulu = 85.7%). These are similar to Adams' results (55.5% of Techikon new intakes, 50.8% of Cell Biology new intakes, 59.7% of first years, and 66.7% of seniors) Nonetheless, 15.8% of the participants from Qhakaza and 24.4% from Buhlebemfundo thought chlorophyll combines with the CO_2 in the presence of light energy and produces glucose and water. The mean confidence for their response was high at 2.99. Qhakaza participants had the mean confidence of 2.84, Buhlebemfundo (2.7) and UniZulu was highest with 3.42 (Table 12).

Table 12: Percentage of students selecting two-tiered options for question twelve.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	15.8	42.1*	15.8	5.3		78.9	2.84
Buhlebemfundo Grade 12	45	A B C D	24.4	51.1*	8.8	2.2		86.7	2.99
UniZulu First Year (BIS)	7	A B C D	0	85.7*	0	0		85.7	3.42

Correct answers are indicated with asterisk (*)

Question 13

Question 13 required students to identify the net reaction equation of respiration. Unlike in Adams' study where results ranged from 52.5% to 83.1%, here about a quarter could identify the equation (26.3% of Qhakaza, 28.9% of Buhlebemfundo and 28.6% of UniZulu respondents). Even fewer could fully interpret the equation and identify products and reactants (5.3% of Qhakaza, 6.7% of Buhlebemfundo and 14.3% of UniZulu). The performance was poorer than that reported by Adams where many students gave a performance of around 50% (27.9% of Techikon new intakes, 42.4% of Cell Biology new intakes, 53.2% of first years, and 54.5% of seniors). This illustrates the misconception identified by Adams (1998) that most students think

respiration and photosynthesis are opposite processes. The confidence was high with the overall mean of 2.84 (Qhakaza had 2.55, Buhlebemfundo 2.77 and UniZulu 3.2) considering that the performance was very poor on this question (Table 13).

Table 13: Percentage of students selecting two-tiered options for question eleven.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Qhakaza Grade 11	19	A B C D	0	26.3	0	5.3*		26.3	2.55
Buhlebemfundo Grade 12	45	A B C D	2.2	4.4	15.6	6.7*		28.9	2.77
UniZulu First Year (BIS)	7	A B C D	14.3	O	0	14.3*		28.6	3.2

Correct answers are indicated with asterisk (*)

In answering question thirteen, most learners selected the correct summary equation for respiration. However, far fewer of these could interpret the equation correctly. This may be due to a lack of understanding of the processes involved.

In discussing these results, it is important to note that the small sample size from UniZulu makes generalisation for this group more difficult. However, data were analysed to see if there were any differences between data collected from the three sites (Fig. 7.11). Independent-Samples t-test analyses showed is no significant difference between the performance of learners from the Qhakaza, Buhlebemfundo and Unizulu.

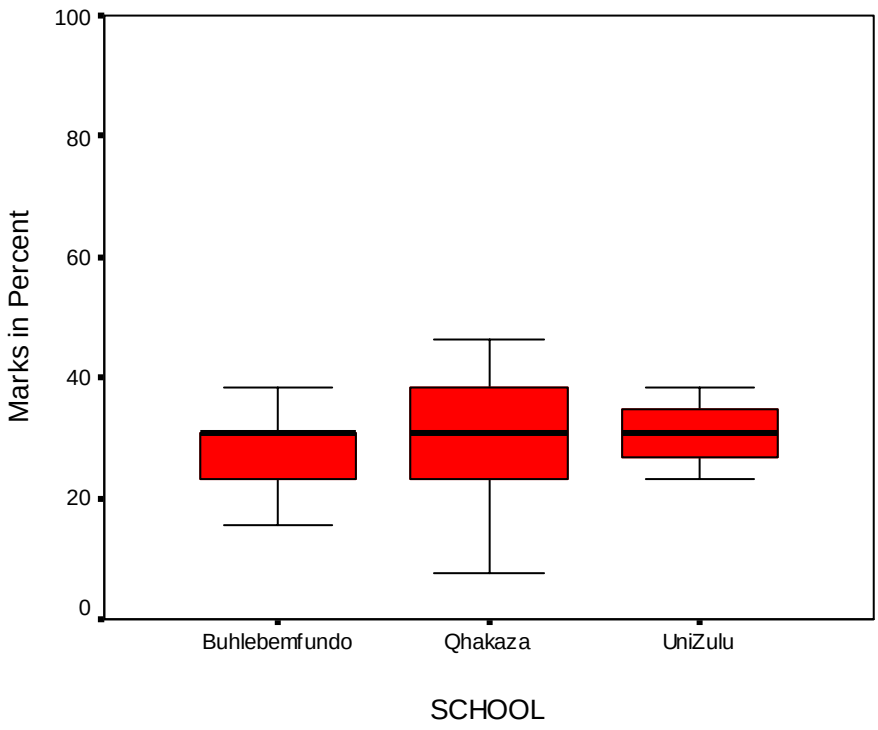

Figure 7.11: Statistical comparisons of results from the three schools.

7.3. REFLECTION AND DISCUSSION

Adams (1998) found that learners confused the relationship between photosynthesis and respiration and considered these processes to be opposites. Teachers may also perpetuate this misconception. For example, material prepared for Utah State 8th grade pupils stated that respiration is almost the 'exact' opposite reaction to photosynthesis (Westbroek, 2000). Learners at this level have not really grasped the nuances of language where they can understand at first glance that the 'almost' in that sentence highlights the differences. Hudson (2001) asserts that in the absence of light, the process of respiration is the opposite of photosynthesis and never mentions the complementarities of the processes. Although *Zadarh* participants had problems explaining how they arrived at their answers, they realised that the two processes were not opposites but complemented each other. It was observed while they were playing *Zadarh* that many realised through their interaction with the 'piano' that by just reversing the processes of photosynthesis, that is by just revising keys they played, no respiration took place. Players often struggled with this part of the game.

Many students, after playing *Zadarh*, still harboured certain misconceptions relating to products and reactants of photosynthesis and respiration processes. With regard to photosynthesis few

learners comprehended that photosynthesis is dependent on light and respiration is not. Many learners thought that oxygen was a by-product of photosynthesis instead of realising that during photosynthesis more oxygen is produced than is needed for respiration and other processes and the excess gas is given off. Pertaining to respiration processes some learners thought that plants did not respire and thus, were unaware that oxygen absorbed by plants was used for respiration.

Again, learners demonstrated lack of understanding of the role of light and dark phases of photosynthesis. The performance was poor on these questions with few students able to identify complementary of the processes. The main problem was the confusion of times as to when these processes do happen.

Students struggled to identify the 'light compensation point' and the significance of the different points on the curve. The majority thought it is the point at which more photosynthesis took place. Students did not understand that the rate of photosynthesis reaches a point where it remains constant even if the light intensity is increased.

Results presented above from playing *Zadarh* suggest that misconceptions appear not to be overcome by only playing educational games and hence, the argument that solving puzzles (authentic tasks within the narrative of the game) result in deep learning (Amory, 2001) may not apply. These results presented here support those of Adams (1998) who argued that there is a need for change of learning strategy for improvement to be realised. Adams allowed learners to play *Zadarh* for one hour only while students from Qhakaza, Buhlebemfundo and Tholokuhle played the game for many hours over a number of weeks. However, participants in this study were enthusiastic and were able to solve the puzzles. Therefore, it is difficult to understand why learners, even after playing for many hours, still did not understand the processes involved.

It was noticed, however, during game-play that many participants stopped trying to discover information and solving puzzles but instead worked hard at beating their peers by attempting to finish the game in the fastest possible time. Again, it appeared that memorization of the solutions to puzzles seemed to play a role in this competition between players. It was observed that most students wanted to get answers from their peers, that is, they wanted others to tell them how they managed to reach certain positions. Once this was explained the next question was invariably, “what do I do ‘next’ to get out of here?” This might reflect on the way in which most learners were taught to think: they wanted to play the game in a linear style instead of realising that *Zadarh* is designed in a way to accommodates each one of them and their unique way of looking at life in general, and their unique approaches to problem solving. Learners fell

into what Lock (2003) calls 'playing without thought' where frequently-used segments of the game are memorised for reuse later. Therefore, it appears that learners reverted to their predominant mode of learning (rote) even when presented with learning tools designed to engage them in authentic tasks. This resulted in the lack of understanding of the processes involved in photosynthesis and respiration.

The results, however, reveal two observations. The first is the reality of the deep-rootedness of the misconceptions. Thus, in discussing the results in general one of the critical observations made was that most learners demonstrated a high preponderance to sticking to the old ways of learning and showed uneasiness to be explorative, flexible and non-linear in their approaches to playing *Zadarh*. The second observation relates to the approach of learners when faced with difficult tasks. When playing *Zadarh* the majority of learners looked for answers from their peers instead of trying to solve the game puzzles. They did not comprehend the importance of solving these puzzles which could be helpful not just in the game but also in the development of their cognitive and critical skills. The rapid technological changes and information explosion force students to develop and effectively apply critical thinking skills to their academic studies, to the complex problems that they face, and to the critical choices they make as a result (Oliver and Utermohlen, 1995). The results show that these learners are a product of a rote learning approach which does not allow them the freedom to be independent thinkers but which according to De Lisle (1997) focuses only on facts to be learned uncritically. The education system appears not to teach these learners to be critical, to reason and reflect, and apply knowledge by means of skills rather than learned facts by rote. These results support Adams (1998) who argued that alternative teaching approaches need to be adopted to overcome such problems as deep-seated misconceptions. Such social constructivism methods advocate learning through teamwork and accommodate cultural differences, and learner experiences.

The results presented in this section suggest that deep-seated misconceptions remain after playing an educational game specifically designed to address misconceptions related to photosynthesis and photorespiration. It is argued that when learners experience new challenges they appear to revert to their predominant mode of learning which in this case appears to be rote learning, where memorisation and regurgitation of what is learned is paramount. Pulkkinen and Ruotsalainen (1997) argue that the social aspect of constructive learning is important because collaborative methods of learning develop critical thinking through directing learners towards discussion, clarifying their own ideas, and evaluating others' ideas.

7.4. REANALYSIS OF PROBLEM

In this present context, where learners learning abilities are set in the rote learning mode, which does not provide space for a mind that is explorative, flexible and inquisitive, the results (above) reveal that game-based learning founded on modern educational theories alone cannot attain expected results of enhancing skills. Learners who participated in the game encountered many problems and most of them needed some extra help as they struggled with the content of the game and its environment. Knowledge is a human product that is socially and culturally constructed (Gredler, 1997) and therefore, by working or playing individually these learners were not gaining any knowledge and their cognitive skills did not improve. Based on Doolittle's (1999) assertion that 'knowledge is the result of social interaction and language usage, and thus is a shared, rather than an individual, experience' additional investigations studies were undertaken. Backgrounds of people involved in the construction of knowledge are paramount. Swortzel (1999) raised a few epistemological tenets of social constructivism: (i) Knowledge is a result of shared social experiences and social negotiation of meaning; (ii) Knowledge is a consequence of shared experiences between individuals and is mediated through language. This means that an individual cannot alone effectively and efficiently construct knowledge; (iii) Knowledge is bound to a specific time and place, hence, the assertion that it is socially and culturally based; and (iv) Knowledge acquisition is based on dialogue. Consequently, communication is central to learning in the social constructivism environments. Hence, Educational Communication and Technology Agency (2004) report raised the lack of communication as one of the major weaknesses of games such as *Zadarh* which are designed for a single user with limiting effect on promoting collaborative learning.

Therefore, to investigate the value of social interaction during game-play and in order to encourage collaborative learning, learners played *Zadarh* in groups. These learners were requested to collaborate with each other by sharing computers, playing together and communicating with each other. Each group consisted of four learners two sharing a computer. Learners were also asked to discuss their decisions for the choices they made and ask each other for clarification where one was needed.

7.5. EVALUATION AND TESTING OF SOLUTION IN PRACTICE

7.5.1. Participating Schools

Only Qhakaza High School, with 13 Grade 12 participants, were selected to participate in this exercise. The group consisted of a similar number of boys and girls who played *Zadarh* for a total of 8 hours over 4 days. These participants were a different set of learners to those

previously participated in the study consequently direct comparisons are difficult as the sample are not the same individuals, and the sample is small. However, it could be argued that although caution needs to be exercised in providing direct comparisons, under the circumstances these samples do represent the same population and based on these certain generalisation could be made.

7.5.2. Materials and Tools

A questionnaire, similar to that used in the previous investigation contained only 8 of the previous questions: 4 poorly and 4 well answered question from the previous investigation were selected. In addition, group tasks were created where learners were asked to find puzzles that supported the reason statements (tier 2 questions) of the questionnaire. As before, the first tier questions probed concepts or relationships between the photosynthesis and respiration and the third tier asked students to rate their confidence in their answers.

7.5.3. Procedures

In this study, decisions were reached through teamwork, negotiations and some support from the researchers during the game play. From the previous part of the study, it was recognised that some learners were good in playing *Zadarh* but struggled with the written test. Consequently, a group of ten learners took a written test (group 1) while another group of 3 learners did the oral test (group 2). Learners taking the oral test were given limited help by way of clarifying questions they did not understand. In the next section, results for this part of the investigation are first presented and then these findings are compared to those from the previous investigation.

7.5.4. Questionnaire Results

7.5.4.1 Results for students working in groups/pairs

The findings show that although misconceptions still existed. Nevertheless, there was great improvement with learners working in groups performing better than those working alone (see Annex 3 for questions). It is important to note that the improvement in the results is attributable to working in groups and the higher level of support, received from the researcher, in terms of clarifying the less understood concepts and probing questions where learners were stuck.

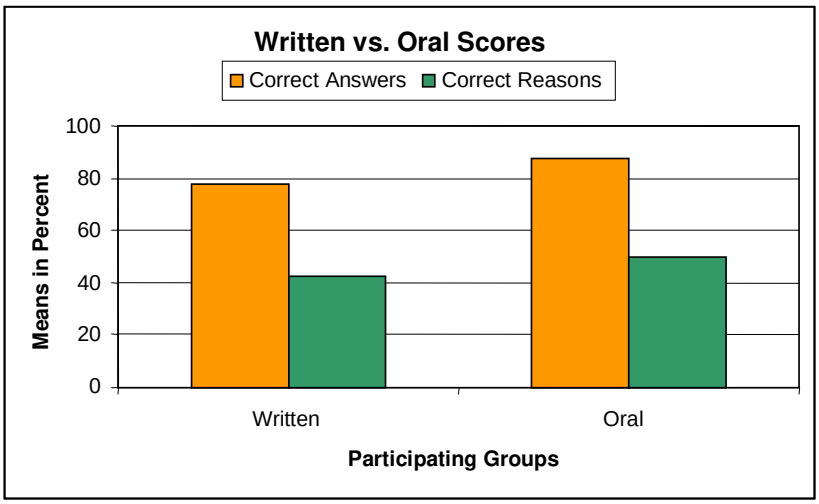

Figure 7.12: Results of Qhakaza learners working in groups

Group 1 had an average score of 75% for the correct answers and 42.5% for the correct reason while Group 2 with an average of 90.5% for the correct answers and 50% for the right reasons outperformed the other groups (Fig. 7.12). From the previous study individuals working alone averaged 61.9% for the correct answers and 29.4% for providing the right reasons. The next section analyses each question (Fig. 7.13).

Question 1

Question 1 asked which gas is released in large amounts in the presence of sunlight. Most students correctly chose oxygen (Group 1 = 90% and Group 2 = 66.7%). However, only a few students grasped the processes involved (Group 1 = 40% and Group 2 = 33.3%) by giving the correct reason that more oxygen than is needed for respiration and other processes is produced by the plant during photosynthesis, so the excess gas is given off. The mean confidence for their answer was high (Group 1 = 2.9 and Group 2 = 3.3) (Table 14).

Table 14: Percentage of students selecting two-tiered options for question one.

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	30	10	40*	10		90	2.9
Oral Test (Group 2)	3	A B C D	33.3	0	33.3*	0		66.7	3.3

Correct answers are indicated with asterisk (*)

Question 2

Table 15: Percentage of students selecting two-tiered options for question two

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	0	60*	20	0		80	2.7
Oral Test (Group 2)	3	A B C D	0	33.3*	0	66.7	0	100	2

Correct answers are indicated with asterisk (*)

Question 2 asked which gas is absorbed in largest amounts in the presence of sunlight. Most students correctly answered that it was carbon dioxide, (Group 1 = 80% and Group 2 = 100%). However, 60% of Group 1 and 33.3% of Group 2 provided the appropriate reason that photosynthesis is light dependent. The mean confidence was medium (Group 1 = 2.7 and Group 2 = 2) (Table 15).

Question 3

Question 3 asked which gas is absorbed in largest amounts in the dark. Oxygen was correctly selected by 70% of Group 1 and 33.3% of Group 2. Nonetheless, only 30% of Group 1gave the correct reason with the medium mean confidence of 2.7. Group 2's medium mean confidence was 2.33 and 66.7% provided the correct reason (Table 16).

Table 16: Percentage of students selecting two-tiered options for question three

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	0	20	30*	20		70	2.7
Oral Test (Group 2)	3	A B C D	0	0	66.7*	0		66.7	2.33

Correct answers are indicated with asterisk (*)

Question 4

Question 4 asked which gas is released in largest amounts in the absence of light. Majority of students correctly selected carbon dioxide (Group 1 = 80% and Group = 100%). However, none

of Group 2 gave the correct reason for their answer but 70% of Group 1 correctly stated that respiration is a process that takes place all the time; the mean confidence expressed was low for Group 2 at 1.67 and medium for Group 2 at 2.6 although they provided the wrong reason (Table 17).

Table 17: Percentage of students selecting two-tiered options for question four

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	70 *	0	0	10		80	2.6
Oral Test (Group 2)	3	A B C D	0*	33.3	33.3	33.3		100	1.67

Correct answers are indicated with asterisk (*)

Questions 1 to 4 dealt directly with the relationship between photosynthesis and respiration, probing students understanding of their products and reactants, and when these processes occurred. Learners working alone (previous investigation) averaged 31.6% on questions 1-4 while those working in groups (written and oral combined) averaged 46.2%. This is an improvement of 14.6%.

Question 5

Question 5 asked when the light phase of photosynthesis occurs. Almost all students knew that photosynthesis occurs only in the presence of light (Group 1 =90% and Group 2 = 100%). Of Group 1 20% who gave the correct reason did not understand the role of light in this process while 66.7% of Group 2 got the right reason; it was believed by 80% of Group 1 that the light phase involved the uptake of carbon dioxide which shows the deep-rootedness of their misconceptions; the mean confidence for both groups was moderate (Group 1 = 2.7 and Group 2 = 2.37) (Table 18).

Table 18: Percentage of students selecting two-tiered options for question five

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	20*	80	0	0		90	2.7
Oral Test (Group 2)	3	A B C D	66.7*	0	0	33.3		100	2.33

Correct answers are indicated with asterisk (*)

Question 6

Table 19: Percentage of students selecting two-tiered options for question six

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	10	20	0	30*		60	2.2
Oral Test (Group 2)	3	A B C D	33.3	0	33.3*	0		66.7	2.33

Correct answers are indicated with asterisk (*)

Question 6 asked when the dark phase of photosynthesis occurs. Unlike in the previous test, many students (Group 1 = 60% and Group 2 = 66.7%) knew that the dark phase is simply light independent, and thus takes place continuously, in the presence or absence of light. However, they appeared not to understand the reasons for their choice as the confidence were low (Group 1 = 2.2 and Group 2 = 2.33) and only a few gave the correct reason (Group 1 = 30% and Group 2 = 33.3%) (Table 19).

Question 7

Question 7 explicitly asked about the relationship of the light phase and dark phase of photosynthesis. The majority of participants identify these as complementary processes (Group 1 = 70% and Group 2 = 100%). A small number of students who could identify products and functions of each phase comprised 20% of Group 1 and 66.7% of Group 2. Many students believed the light phase involved the uptake of carbon dioxide. Group 2 had a high confidence of 3.33 but Group 1's poor mean confidence of 1.7 illustrates the lack of understanding of these concepts (Table 20).

Table 20: Percentage of students selecting two-tiered options for question seven

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	20*	10	40	0		70	1.7
Oral Test (Group 2)	3	A B C D	66.7*	0	33.3	0		100	3.33

Correct answers are indicated with asterisk (*)

Questions 5-7 show that, although there were some improvements when learners worked in groups, there was a lack of understanding of the role of light and dark phases of photosynthesis and respiration. Performance was poor with learners working alone (previous investigation) with the mean of 16.4% while those working in groups averaged 33.3%. This is an improvement of 16.9% more learners being able to identify these as complementary processes.

Question 8

Table 21: Percentage of students selecting two-tiered options for question eight

School-Year of study	No of Students	Content Choice	Reason Choice					Total %	Mean Confidence
			A	B	C	D	E		
Written Test (Group 1)	10	A B C D	10	20	40*	0		70	2.3
Oral Test (Group 2)	3	A B C D	0	33.3	33.3*	33.3		100	2.67

Correct answers are indicated with asterisk (*)

Question 8 examines student understanding of the relationship between photosynthesis and respiration. A figure was shown representing a light response curve and students were required to identify the light compensation point. Most learners (Group 1 = 70% and Group 2 = 100%) could indicate the light compensation point unlike in the previous investigation where they could not. Fewer students (Group 1 = 40% and Group 2 = 33.3%) though could interpret its significance which is that at this light intensity the rate of photosynthesis equals the rate of respiration. Both groups obtained a mean confidence (2.2 for Group 1 and 2.67 for Group

2)(Fig. 21). However, in the previous investigation most students struggled with identifying the 'light compensation point' and thought it is the point at which more photosynthesis took place. There was a huge improvement of 32.7%, from 13.5% for students working alone to 46.2% for those working in groups.

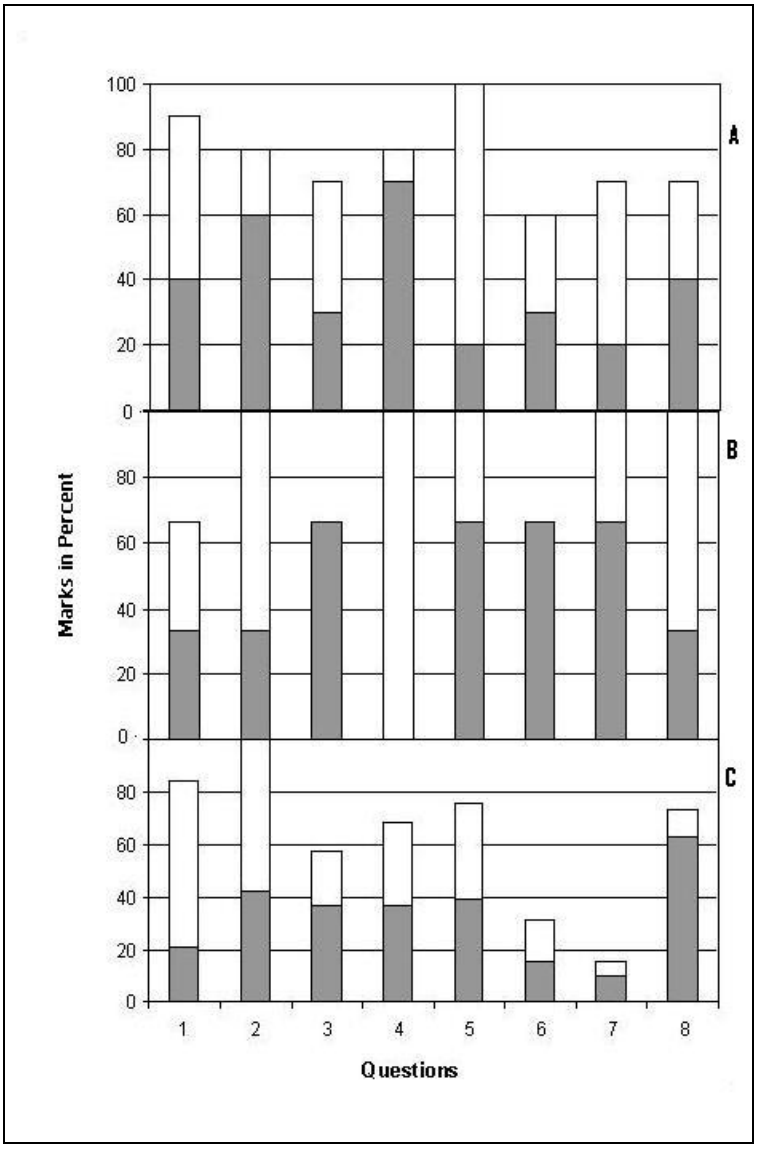

Figure 7.13: Percent of correct answers given by three participating groups from Qhakaza High School, (A) Group 1 (Written), (B) Group 2 (Oral) and (C) individuals (From the previous test). The shaded represents the percentage that identified the correct reasons.

7.5.4.2 Analyses of results for students working individually and in groups

In this section results for student who worked individually are referred to as Group A (taken from the previous investigation; n = 19) and for students who worked in a group are referred to

as Group B (results for Group 1 and Group 2 of this part of the investigation were merged; n = 13). All participants were from Qhakaza.

Question 1

Question 1 asked which gas is released in large amounts in the presence of sunlight. Majority of both groups correctly chose oxygen (Group A = 84.2% and Group B = 84.6%). However, only 21.1% of Group A and 38.5% of Group B correctly understood that more oxygen than is needed for respiration and other processes is produced by the plant during photosynthesis, and therefore, the excess gas is given off. There was a 17.4% improvement when learners played together.

Question 2

Question 2 asked which gas is absorbed in largest amounts in the presence of sunlight. Most students correctly answered that it was carbon dioxide, (Group A = 100% and Group B = 84.6%). Many from the two groups understood that photosynthesis is dependent on light (Group A = 57.9% and Group B = 53.8%). Both groups appeared to hold similar views.

Question 3

Question 3 asked which gas is absorbed in largest amounts in the dark. Oxygen was correctly selected by 57.9% of Group A and 69.2% of Group B. There was an improvement in the scores (17.4%) for choosing the correct reasons as 21.1% of those working alone and 38.5% of learners working in group knew that oxygen absorbed is used in respiration.

Questions 4

Question 4 asked which gas is released in largest amounts in the absence of light. Majority of students correctly selected carbon dioxide (Group A = 68.4% and Group B = 84.6%). However, 31.6% of learners working alone and 53.8% of those working in groups correctly reasoned that respiration is a process that takes place all the time (an improvement of 22.2%).

Question 5

Question 5 asked when the light phase of photosynthesis occurs. Most learners knew that it occurred only in the presence of light (Group A= 75.9%, Group B =100.0). The role of light in this process was not well comprehended with only 36.3% of Group A and 30.8% of Group B aware that the light phase involves electron transport, which only takes place when sunlight excites chlorophyll molecules, causing them to give up electrons. Individuals performed 5.5% better than groups and therefore, there was no improvement.

Question 6

Question 6 asked when the dark phase of photosynthesis occurs and 36.3% of Group A and 61.5% of Group B provided the correct answer. However, the correct reason that the dark phase is simply light independent, and thus takes place continuously was given by 15.8% of learners working on their on and 38.5% of those of those working in groups. More of those working in groups understood this concept.

Question 7

Question 7 asked about the relationship of the light phase and dark phase of photosynthesis. Only 15.8% of Group A and 76.9% of Group B were able to identify these as complementary processes. The correct reason for the answer was given by 5.3% of Group A and 30.8% of Group B. There was improvement 25.5% for those working in groups.

Question 8

Question 8 probed the students understanding of the relationship between photosynthesis and respiration. A figure was shown representing a light response curve and students were required to identify the light compensation point. Group A had the mean score of 73.3% and Group B had 76.9%. The right reasons were given by 10.5% of Group A and 46.2% of Group B who knew that at this point the rate of photosynthesis equals the rate of respiration.

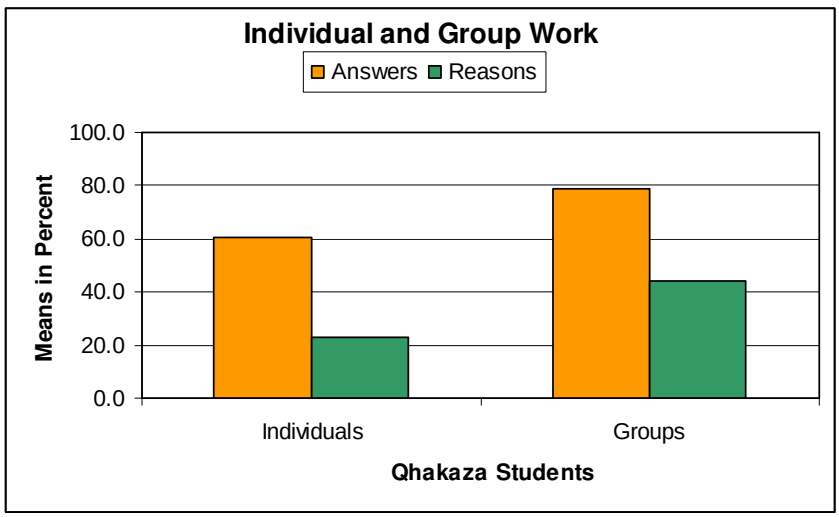

Figure 7.14: Mean scores for Qhakaza Learners who played *Zadarh* individually or in groups

The results of the two groups indicated that Qhakaza students who worked alone attained an average score of 60.5% for the correct answers and 23% for selecting the correct reason for those answers; Qhakaza learners working in groups (Group B) averaged 79.8% for the correct

answer and 44.4% for the right reasons (Fig. 7.14). Therefore, those learners who discussed their interactions and game-play choices with their colleagues (*social dialogue*) were able to answer more questions correctly but were also able to provide the correct reason for their choices**.**

The results presented above were analysed using the nonparametric statistical test because of the smallness of the sample. It is argued that small samples usually pass a normality test and therefore, it is a mistake to test every data set for normality, and use the result to decide between parametric and nonparametric statistical tests; on the other hand, nonparametric methods are most appropriate when the sample sizes are small (StatSoft, 2003). Therefore, in the first part, students (n=13) who took the written test were compared to those who did the oral test using the nonparametric Wilcox Test which detects differences in the distributions of the two related variables. This test produced the negative sum of ranks of 91 and the significant difference of $p = 0.001$ which indicates that the two variables are significantly different. These results suggest that learners taking oral test performed better than those taking the written test. This supports the earlier finding that language can influence measures of performance. Secondly, results of Qhakaza learners working alone were compared to those of learners who worked in groups (oral and written tasks combined). Again, because of the small samples involved the nonparametric Wilcox test, which is an alternative to a paired samples t-test, was carried out. With respect to the correct answers given by learners working alone versus of those working in groups (tier 1 questions) the Wilcox mean rank of negative 16.50 indicates that learners working in groups outperformed those working as individuals. The low significant value of $p < 0.001$ indicates that the two groups are significantly different. According to the Wilcox Signed-Rank test distributions of performance is greater for those learners working in groups. Similar results were attained when the means for the correct reasons were also subjected to the Wilcox test. The Wilcox mean rank of 22 indicates that learners working in groups perform better than when working alone. The low significant value of $p < 0.001$ indicates that there is a substantial difference between the two groups. Again, the distribution is skewed towards those learners working in groups. Therefore, Qhakaza learners, and by extension learners from the disadvantaged communities, perform better when they engage in team work.

7.6. REFLECTION AND DISCUSSION

Results presented is this section clearly show that while learners who worked in groups still harboured misconceptions, they clearly understood the processes of photosynthesis and respiration better than their peers who played *Zadarh* individually. The results confirm the important assertions made by many scholars that working in teams improve people's critical

skills and that small-group, cooperative instruction has a powerful effect on a variety of additional outcome measures, including higher-order (critical) thinking skills and cognitive development (Cooper and Robinson, 2002). Simon (2001) argues that constructivist theories of human functioning must acknowledge that individuals cannot alone effectively construct meaning.

Cooper and Robinson (2002) say that when peers work together there is a great deal of modelling, cognitive disequilibrium, feedback and perspective taking emerges as students explain and receive explanations from their colleagues. Even if people are not of the same mental capacity they still learn from each other because they bring different skills to learning. Chee (1997) warns that although collaborative learning works, cognisance must be taken of the fact that if weak students are grouped together the level of improvement is not the same as grouping together stronger learners. For example, in the exercise carried out to teach one of Shakespeare's books, *Macbeth*, it was found that weak learners when arguing their case muddled their thinking by combining both position of prosecution and defence of Macbeth. They were unable to substantiate their viewpoints with facts and evidence from the play.

These results illustrate the point that 'knowledge is the result of social interaction and language usage, and thus is a shared, rather than an individual, experience' (Doolittle, 1999). Cooper and Robinson (2002) argue that when the National Science Foundation project directors were asked to evaluate which of the 13 possible innovations in their undergraduate teaching was central to effective teaching of students, working in teams was ranked the highest. From the cognitive perspective, small-group instruction allows students to cognitively rehearse and relate course material into existing schema or conceptual frameworks, thus producing a deeper, contextualized level of understanding of content (Kurfiss, 1988).

7.7. ANALYSIS OF PROBLEM - THE USE OF *YKHOZI* IN PROMOTING SOCIAL CONSTRUCTIVISM

7.7.1. Introduction

The educational game *γKhozi,* developed to overcome the technical navigational problems previously identified in *Zadarh*, is designed as a social constructivist learning environment where co-operation amongst learners is a vital part of game play and is created to host a number of different microworlds. The findings from the literacy and communication skill tests were considered whey yKhozi was developed in order to place the game content at the appropriate level while still providing quality information. The previous sections clearly indicate that

playing in a group helps learners overcome misconceptions. Furthermore, it was discovered that learners from semi-urban areas lack the skills to successfully undertake tertiary education. Therefore, can the use of educational microworlds developed in the form of games where learners are encouraged to play and communicate with each other develop skills such as literacy and communication? The following stuffy tried to ascert6ain the importance of play done through social interaction and dialogue in the development of basic skills such as visualisation, numeracy and logic.

7.7.2. Objective

The aim of this second part of the study was to determine whether *γKhozi* can effectively address and improve literacy and communication skills of learners playing in groups. The use of *yKhozi* is interesting because it covers two aspects of learning which were quite diverse. The researcher tried to investigate the ability of *yKhozi*, a game which covered the topics of diseases (Cancer, tuberculosis and HIV/AIDS), to develop learners' cognitive skills, particularly their literacy and communications skills. This study considered as pre-tests the studies and results attained in the previous sections, e.g. 6.2, 6.3, where learners worked and answered questions individually and 7.5 where they worked in teams/pairs but gave individual answers. It is, therefore, the objective of this part of the study to ascertain if playing *γKhozi* in groups and answering questions in groups, i.e., engaging in a social constructivist learning can improve skills. The paper-and-pencil test to measure literacy and communication skills based on POM principles (Chapter 5) was used to investigate skill development after game-play.

7.8. EVALUATION AND TESTING OF SOLUTION IN PRACTICE

7.8.1. Participating Schools

Participants in this part of the study included 2005 Grade 12 students from Buhlebemfundo Secondary School. As it was the intention to compare the results of these participants with those that participated (referred to as students from 2003) in the development and evaluation of the skill questionnaire (Chapter 5) it is necessary to first investigate the similarities between these two groups. The academic records of these two groups was therefore investigated. The samples from 2005 consisted of 55 learners and the sample from 2003 of 51 learners. Their performance in their Grade 11 final (2003 – 46.54%, 2005 - 42.44%) and English (2003 – 37.96%, 2005 – 37.84%) examinations were similar. The Independent Samples t-test showed that there was no significant difference between these groups ($p = 0.058$ for final examinations; $p = 0.933$ for English examination). The data for this section were collected between February and May 2005.

7.8.2. Tools and Materials

For this part of the study, one *γKhozi* portal or microworld used was designed to provide players with knowledge related to viruses and bacteria, HIV/AIDS, and Cancer and Tuberculosis. The setting of the game is in a rural African village. After playing *γKhozi* for about 16 hours over a period of 4 weeks, learners were asked to answer a set of questions which evaluated their literacy and communication skills (see Chapter 5). In this part of the study learners played and answered the questions in groups of three, where they would discuss a question and give one answer. However, to ensure that the actual learning was really taking place, learners were rotated and encouraged to work with people they had not previously worked with. This was to encourage those who were weak not to lose interest in the game as they would get help from the more able players. Learners were allowed to spend as much time on the questionnaire as they required and the average time they spent was one hour fifty minutes for the 80 questions.

To evaluate the practicality and effectiveness of the game, participants were requested to play *γKhozi* for as many hours as they wished and thereafter were asked for their opinions in a short questionnaire. During play, the researcher also made certain observations. After playing the game a focus group was formed which consisted of 6 learners (3 of each sex) from Buhlebemfundo with the aim of ascertaining whether learners thought that games like *γKhozi* are needed in schools. Since the session was held in English, the learners were given structured questions 10 minutes before the session so that they could start formulating their answers. When the session began, they were all eager to be heard.

7.8.3. Game Environment

Although all these learners had no prior experience with computers, it was observed that they were able to move easily within the game environment after a few sessions. The first day was spent trying to familiarise participants with the mouse movement and the game environment. Problems encountered later were solved with the assistance of those learners who had come to grips with the mouse movement and game environment.

Regarding the interest in the game, both male and female were eager to play the game and none wanted to leave the classroom at the end of each session. At this stage of the study only12 to 15 volunteer-students were needed to take part in the study. However, more than 36 participated in the study which remained fairly constant throughout this part of the study. At times participants experienced problems such as the computers freezing and the classroom becoming too hot. However, they attempted to solve such problem by suggesting that the computers could be spread around the classroom and boys and girls could attend alternate sessions. This second

solution created a small problem as the information was never communicated to the researcher and one day there were no male participants. However, due to continuous technical problems at the School LAN and the instructivist nature of the learning environment at the School, learners were later bussed from their school to a LAN at the UKZN, which was air-conditioned, and where fewer technical problems arose.

7.8.4. Results of Focus Group Analysis

On the questions about learners' impressions about games like *γKhozi* and whether they think are needed in schools most students answered affirmatively (See Annex 4 for questions). They felt that *γKhozi* was informative about causes and prevention of HIV/AIDS, TB and Cancer. The names used below are fictitious.

Peter said, "I absolutely love the word-puzzle and the matching game where you match all the causes and preventions of AIDS".

Busi added, "From reading on books even your English language improves". She went on to state that the game would help teenagers to make informed decisions about their lives regarding the killer diseases.

Mbuso replied, "Yes, because it really teaches us on how diseases can be cured and how they occur and their symptoms on how you can determine that this person is suffering from which disease."

Mbuso raised another important issue of enjoyment during play and she said, "It (*γKhozi*) is not difficult to play but it is also fun to listen to some of the people when they talk and crack jokes when they play".

On the question of whether *γKhozi* was easy to play, in terms of interface and navigation many learners answered yes. There was a divergence of opinions regarding the skills needed and most learners stated that the ability to use a mouse and reading were essential.

Lawrence was comprehensive in his answer as he thought that important skills needed were, use of mouse, reading, application of information, and being able to follow instructions. Busi listed the ability to listen as another important skill.

However, there were those who believed that to use the mouse was not a skill and therefore, answered that no skills were needed. For example, Linda in supporting that no skills were necessary stated, "You use mouse all the time and the computer tells you what you can do".

Mbuso in agreement expressed, “All the instructions are simple as you just follow the red or orange arrow”.

On the question of which different games learners liked most, many learners claimed that they liked to play card games and puzzles (Mbuso, Jali, Langa), any computer games which were not violent (Busi) and educational games (Linda).

On the question of what they did not like about *γKhozi*, most learners stated that they liked everything. However, some stated that they disliked being stuck and not knowing what to do next.

Busi said, “I don’t like it when I get stuck and sometimes I am clueless about information”.

Peter declared, “I don’t enjoy it when I get stuck in one place and I can’t move to the next level until some one comes to help us”.

Busi did not realize that clues could come from other learners while Peter acknowledged this part but just does not like working as part of a group.

On the question of what they learned while playing *γKhozi*, all stated HIV/AIDS, TB and cancer. Most learners stated that they now had a better understanding of the diseases and their prevention. Mbuso, Linda and Jali showed that they learned about computers and communication skills. Busi asserted that the most important skill she acquired from *γKhozi* was working in a team. Lawrence expressed that he learned about cultures of other African people as he had never been in a roundavel (roundhouse) and never seen a mosquito net. Figure 3 below shows the inside of a roundavel with a fire place and a mosquito net and a fire place in the middle.

On the question of how playing *γKhozi* in groups helped them in their work, most raised the importance of working in groups.

Peter said, “It (*γKhozi*) helped us because we learnt to listen to each others advices and suggestions on how to go about the solving different problems”.

Mbuso agreed, “Now I know we don’t understand the same way, and some (people) are friendly and some are cheeky, but we have to work together”.

Lawrence stated, “We share different ideas and different skills”.

On the question of whether *γKhozi* was interesting all learners gave a positively response.
Peter asserted, “Of course, all those beautiful features it has and the lovely Thusano who is always making me laugh makes it all so interesting”.

Mbuso adds, “… especially for a person like me who is doing biology”.

On the question of whether playing the game in groups helped, all answered yes and stated that most parts of the game needed players to discuss some things. Observed was made that majority of learners working individually struggled with matching blood results and therefore, they were forced to talk to each other.

Busi declared, “Yes, because if you play the game alone and you don’t understand clearly there is no one to assist you”.

However, Mbuso felt that working in groups was wasting her time as she wanted to work on interesting parts only and said, “may be it helped even though I understood better playing by myself, playing in groups did not help much because some of us want to jump the topic if it is boring”.

From the discussions learners agreed that *γKhosi* was an easy and practical game to play. They also felt that it was interesting as they engage with game characters like Thusano, the integrated help agent, who also provided some fun as Thusano sometimes gave unintelligible answers. Students felt that the skills learned were usage of computer, communication and working in teams, on top of HIV/AIDS, TB and cancer diseases. Some also mentioned that they learned to listen. Even those who felt that working in groups was a waste of time still stated that they learned to listen and to work in teams.

7.8.5. Skills Test Results

The effectiveness of the game was determined by asking learners to participate in a literacy and communication skills test (See Annex 1 for questions). For analysing this part of the study a quantitative analysis was carried out. The results are divided according to their different categories of visualisation, logic and numeracy, and communication. The results show that the 2005 learners who played *γKhosi* together (referred to here as *Group*) had the overall mean of

63.4% an improvement of 23.5% from the previous average of 39.9% attained by the 2003 group (refereed to here as *Individual*).

7.8.5.1. Visualisation Skills

The overall mean on the visualization skills of 60.8% for students working in Groups is an improvement of 14.1% from the Individuals' mean of 46.7%.

2D Visualisation Skills

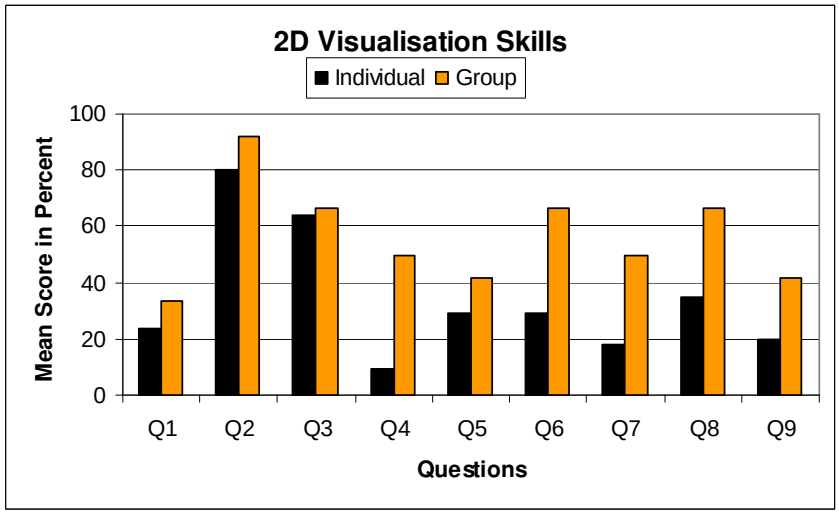

Figure 7.15: 2D skills results of both groups of learners.

In the 2D skills, questions (Fig. 7.15) learners were required to identify two objects made up of the same components but arranged differently. Learners had to visualise the way an object would look like after being rearranged before making their choices. Group learners scored an average of 56.5% and performed 22.3% better than the Individual group who scored 34.2%. Performance improved slightly for questions 1, 4, 6, and 7 involving triangles and rectangles. Question 1 asked learners to identify rectangles containing arcs and only 33.3% of the Group gave the right answer (e), an improvement of 9.6% from 23.7% attained by Individuals. However, many Group learners selected (d), an exact opposite of (e); half of participating students (50%) found the question difficult. Performance was good for question 2, dealing with rectangles, with 91.7% of learners working in groups choosing the correct answer (c), an increase of 11.6% from the 80.1% scored by those working individually.

For question 4, with the correct was answer (e), learners working in groups had the mean of 50% which was an improvement of 40.9% from 9.1% achieved by learners working individually. A third of (33.3%) the students working in groups chose the wrong answer (c) and

50% of them found it difficult. For questions 5 there was an improvement of 12.6% from 29.1% achieved by learners working alone with 41.7% of learners working in groups choosing the correct answer (e). Nevertheless, more students (50%) still chose the wrong answer (a).

For question 6, the correct answer was (d) and students working in groups averaged 66.7% which is an improvement from the previous group (Individual) of 37.6%. For question 7, (c) was the right answer with 50% of students working in groups getting it right and another 50% choosing (b). There was an improvement of 31.8% from 18.2% earlier obtained by learners working alone. On the other hand, 41.7% of the Group learners stated that they found this question difficult.

Questions with arcs and triangles provided some difficulties for most learners. This is seen in question 9 where the correct answer (c) was given by 41.7% of learners working in groups, and the equal number chose (e) as their correct answer. Only 33.3% of these participants claimed that the question was difficult. There was an improvement of 21.7% from 20% achieved by learners working individually.

3D Visualisation Skills

The exercises on 3D skills required the matching of similar figures viewed from different angles. Learners working in groups had the mean of 69.6%, which is a 15.7% improvement on 53.5% scored by learners working alone. Fourteen questions were again used to determine the 3D visualisation skills of learners (Fig. 7.16).

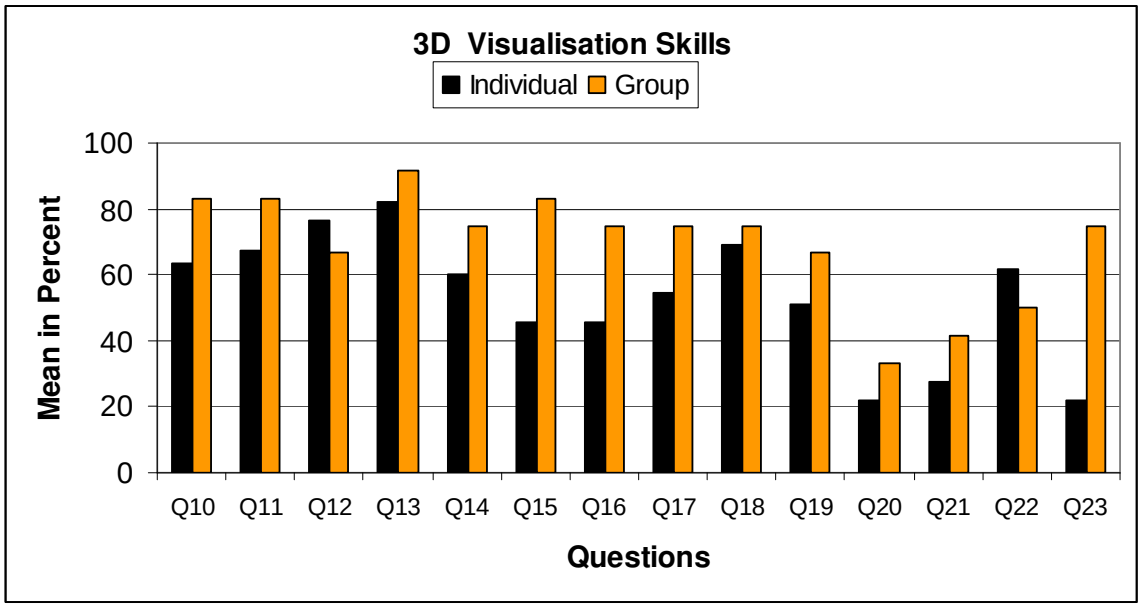

Figure 7.16: 3D visualization skill results for both groups of learners.

Learners working alone performed well in questions 10, 11, 13 and 14 but learners working in groups performed better. All learners were better at 3D than at 2D visualisation. For question 10, the correct answer (d) was chosen by 83.3% of learners working in groups an improvement of 19.6% from 63.7% attained by learners working individually. For question 11 the correct answer (a) was selected by 15.9% of learners working in groups who averaged 83.3%. Learners working alone had scored 67.4%.

For question 12 the correct answer (e) was selected by 76.5% of learners working as individuals, this was 9.8% more than 66.7% achieved by those working in groups. For question 13, the correct answer (c) was chosen by 91.7% of students working in groups, an improvement of 9.8% from 81.9% scored by those working alone. For question 14 (d) was the right answer and 75% of students participating in groups answered correctly, an increase of 14.9% from the 60.1% of those working alone.

For question 20 the correct answer (d) was selected by 33.3% of Group learners, an improvement of 11.4% from 21.9% for those working alone; 58.3% of learners working in groups found this question to be difficult. For question 21, the correct answer was (c). Learners working alone had an average 27.3% while those working in groups achieved 41.7%. About 33% of this group found the question difficult. For question 22, there was a decline of 11.9% from 61.9% attained by students working alone to 50% for those working in groups, who provided the correct answer (b) while another 50% thought that the answer was (c). Again 58.3% of learners working in groups found this question to be difficult.

There was also a huge improvement of 37.8% on question 15 from 45.5% for those working alone to 83.3% for those involved in teamwork. Question 23 showed a great improvement of 53.1% from 21.9% for learners working individually to 75% for those working in groups. Again, questions 16 realised a big improvement of 29.5% for students working in teams from 45.5% for those working alone to 75%. For question 17 learners working alone scored 54.6% and those working in groups scored 75% an improvement of 20.4%. Question 18 results showed an improvement of 5.8% from 69.2% for learners working alone to 75% for learners working in teams. For question 19 learners working in groups scored 66.6% an improvement of 15.7% from 51% attained by those working individually.

2D – 3D Visualisation Skills

Seven questions assessed learners' ability to transform 2D objects into 3D forms by mentally folding, along the perforated lines, flat objects made from pieces of metal or cardboard. This

section did not realise any significant improvement with the score of 48.8% secured by students working in groups and 49.2% attained by learners working alone. Again, learners who played *γKhozi* and worked in groups still showed a lack of mental proficiency to visualise the newly formed 3D objects from the 2D flat sheets (Fig. 7.17).

For question 24, learners had to identify the semi-cylinder with both sides closed: learners working in groups scored 75%. This was an improvement of 12.6% as learners working alone scored 58.3%. However, 16.7% of learners working in groups chose the wrong answer (a).

For questions 25, there was a 1.5% decline in the pass rate from the 18.2% for learners working on their own to 16.7% for those working in groups. Most learners (66.7%) working in groups chose the wrong answer (b) and none of the learners said that they misunderstood the question. There appeared to be confusion between answers (a) and (e).

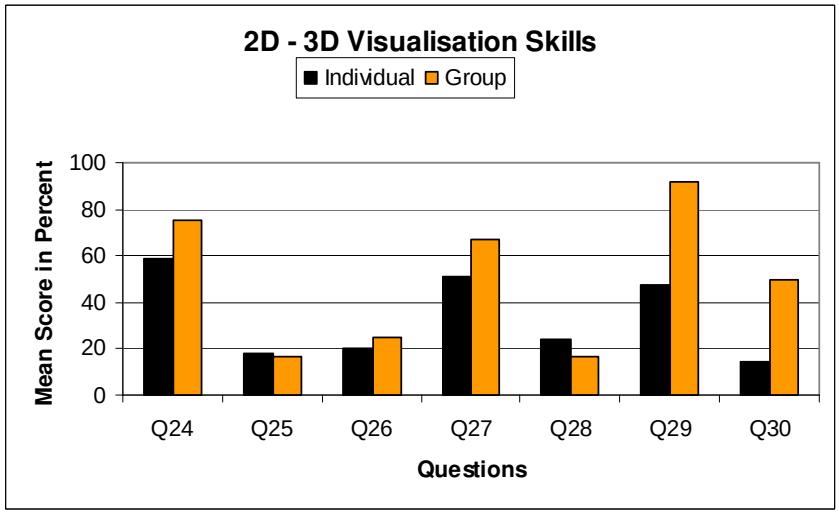

Figure 7.17: 2D to 3D visualization skills for both groups of learners.

For question 26, the right answer (b) was a three-quarter cylindrical shape chosen by 25% of learners working in groups an improvement of 5% from 20% of those working alone. Almost half of learners (41.7%) working in groups chose the wrong answer (c). Again 33.3% of learners working in teams stated that they found this question difficult. For question 27, about two-thirds (66.7%) of learners participating in teams chose the right answer (a). Only 17.2% of all learners selected the wrong answer (b). The majority (58.3%) of those working in groups declared that the question was difficult. For question 28, there was a decline of 7% with 16.7% of learners working in groups choosing the correct answer (b) compared to 66.7% who selected (c). Learners working alone attained the mean of 23.7%.

For question 29, the correct answer (a) was given by 47.3% of learners working alone and there was a 44.4% improvement to 91.7% for those working in groups. However, 50% of learners working in groups found the question difficult. Question 30 was another one badly performed with only 50% of students working in groups correctly choosing (c) and this was an improvement of 35.4% from 14.6% attained by those learners working alone. On the other hand, 50% of learners working in groups chose the wrong answer (d).

7.8.5.2. Logical and Numerical Skills

This section was used to assess the learner's ability to logically distinguish between the numerical and word patterns and to apply them to new contexts. The group's mean score of 56.9% on the logical skills was 19.2% higher than the 37.7% scored by learners working alone (Fig. 7.18a and 7.18b).

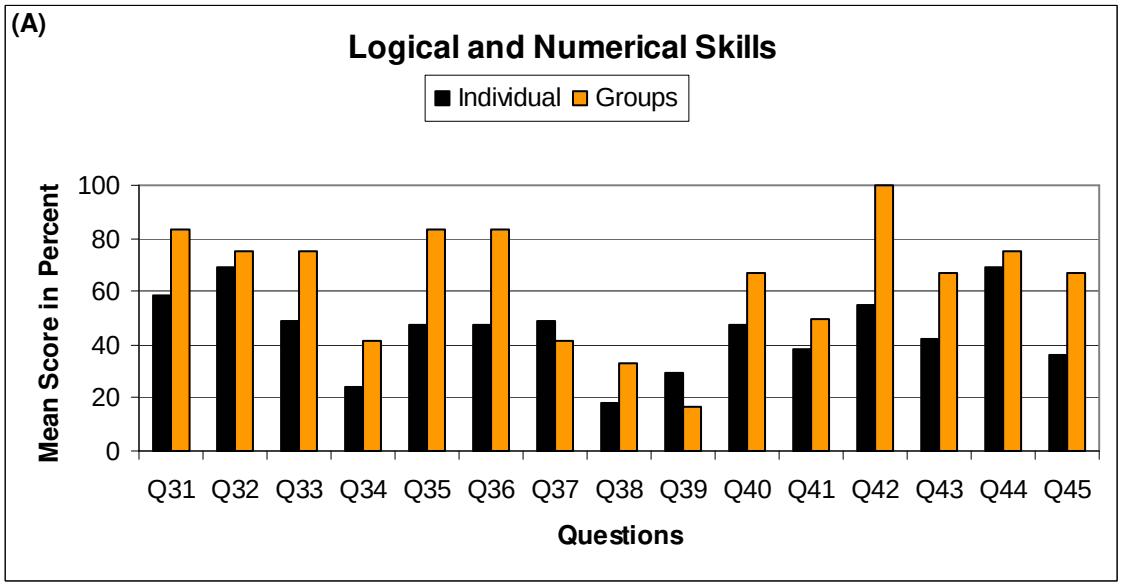

Figure 7.18A: Logical and numerical skills for both groups of learners.

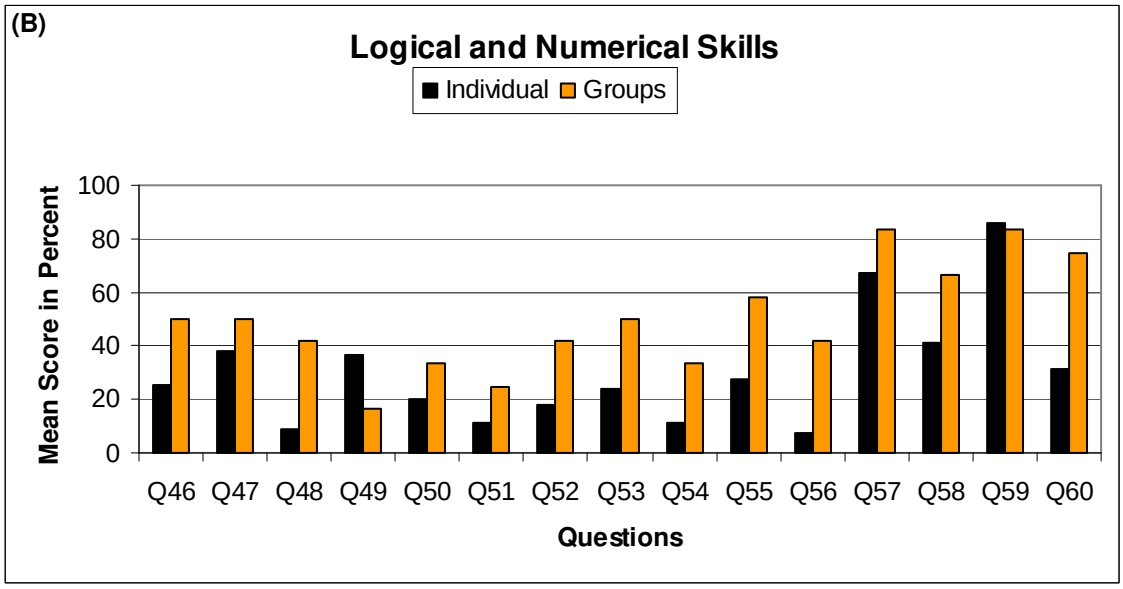

Figure 7.18B: Logical and numerical skills for both groups of learners.

For question 31 the question asked "Which one of the five is least like the other four (a) bear (b) snake (c) cow (d) dog (e) tiger" and the correct answer was (b) because the others were four legged animals. Learners working in groups attained a mean score of 83.3%, an improvement of 25% over 58.3% attained by students working alone.

Question 32 needed the word "BARBIT" to be rearranged in order to form the name of an animal "rabbit". Learners working in groups (75%) scored 5.8% better than those working alone (69.2%) did.

Question 33 asked "Which one of the five is least like the other four (a) Potato (b) Corn (c) Apple (d) CARROT (e) Bean". The correct answer (c) was a fruit, was selected by 75% of students working in teams. This was an increase of 25.8% from 49.2% achieved by participants working alone.

Question 34 asked learners to calculate some basic ratios of the ages of two brothers where, "Salim, twelve years old, is three times as old as his brother. How old will Salim be when he is twice as old as his brother?" Students working in groups scored 41.7% compared to 23.7% by those working alone, an increase of 18%.

Question 35 tried to find the best comparison to "Brother is to sister" therefore "niece is to (a) Mother (b) Daughter (c) Aunt (d) Uncle (e) Nephew" and those learners working in groups

averaged 83.3% by choosing the correct answer (e) “Nephew”. This was an increase of 36% as participants working alone averaged 47.3%.

Questions 36 asked for comparison that if milk is to glass then letter is to what, (a) Stamp (b) pen (c) Envelope (d) Book (e) Mail. The correct answer (c) was selected by 83.3% of learners working in teams an improvement of 36% from 47.3% of learners working alone.

Question 37 attempted to find the best comparison for “LIVE is to EVIL as 5232 is to: (a) 2523 (b) 3252 (c) 2325 (d) 3225 (e) 5223”. EVIL is the reverse spelling of LIVE; the reverse of 5232 is 2325. The correct answer (c) was chosen by 41.7% of learners working in teams, a decrease of 7.5% compared to previous results (individuals).

Question 38 compared three items and wanted to ascertain if the statement "If some Smaugs are Thors and some Thors are Thrains, then some Smaugs are definitely Thrains" is (a) true, (b) false or (c) neither. Those in groups got 33.3% an improvement of 15.1% from 18.2% averaged by learner working alone.

Question 39 asked for the best comparison to “Tree is to ground as chimney is to: (a) smoke (b) Brick (c) Sky (d) Garage (e) House”. The correct answer is (e) “House” and those working in teams averaged 16.7% a decrease of 12.4% from those working individually.

Question 40 asked if the letters "MANGERY" are rearranged what would one get (a) Ocean (b) Country (c) State (d) City (e) Animal”. The answer is (b) “Germany” selected by 66.7% of learners working in groups. This was an improvement of 19.4 from 47.3% of those working alone.

Question 41 wanted to find out “Which one of the five is least like the other four? (a) Touch (b) Taste (c) Hear (d) Smile (e) See”. The correct answer (d) “Smile” was not like the rest because the others are senses while smile is a facial expression, was chosen by 55.4% of all learners. Students working in groups averaged 50% an improvement of 11.8% from 38.2% attained by those working individually.

Question 42 tried to determine who was taller than the others between Sipho who is taller than Peter, and Bill is shorter than Sipho. The right answer was (d) which stated that it is impossible to tell who is taller between Bill and Peter without more information was selected by 100% of

learners working in groups. This was an increase of 45.4% from 54.6% attained by learner working individually.

Question 43 asked for identification of clothing item that was different from others (a) Stocking (b) Dress (c) Shoe (d) Wallet (e) Hat. “Wallet” (d), was the least like the others and was chosen by 61.4% of learners. Participants working in teams scored 66.7% an improvement of 24.8%.

Question 44 compared the sequences of numbers to alphabetical letters and coded CACAACAC as 31311313. Students working in teams averaged 75% by selecting the correct answer (d) “31311313”, an improvement of 5.8% over participants working alone who had 69.2%.

Question 45 asked if the letters "RAPIS" are rearranged what name would one get (a) Ocean (b) Country (c) State (d) City (e) Animal”. The answer is (d) “Paris” was selected by 66.7% of learners in teams and this was an increase of 30.3% from 36.4% who worked alone

Question 46 asked whether the statement "If some Bifurs are Bofurs and all Gloins are Bofurs, then some Bifurs are definitely Gloins" is (a) True (b) False or (c) Neither. The correct answer (b) “False” was selected by 50% of learners working in teams, an improvement of 24.5%, from 25.5% of those working individually.

Question 47 wanted to find the best comparison to “Water is to ice as milk is to: (a) Honey, (b) Cheese (c) Cereal (d) Coffee (e) Cookie”. The right answer was (b) “Cheese” and that “Water changes into ice and milk changes into cheese” was selected by 50% of learners working in teams an increase of 11.8% from 38.2% of those working alone.
Question 48 asked “By what percent must the item be increased to again sell the article at the original price if it was earlier cut by 20%: (a) 15% (b) 20% (c) 25% (d) 30% (e) 40%”. Exactly 41.7% of those working in groups chose the correct answer (c) “25%”, compared to the 9.6% from those working alone. This was an increase of 32.6%.

Question 49 tried to ascertain, “Which one of the five is least like the other four? (a) Bottle (b) Cup (c) Tub (d) Funnel (e) Bowl”. The answer was (d) “Funnel” as the others hold liquids while liquids pass through a funnel. The mean score for those writing in groups was 16.7% a decrease of 19.7% from 36.4% for those working individually.

Question 50 asked how many cookies did Musa start with if after eating one and giving half the remainder to her sister she ate another cookie and gave half of what was left to her brother she

was left with five (a) 11 (b) 22 (c) 23 (d) 45 (e) 46. Only 33.3% of team players correctly chose (c) “23” an improvement of 13.3% from 20% of those working on their own.

Question 51 tried to ascertain the difference between metals and non-metals (a) Copper (b) Iron (c) Brass (d) Tin (e) Lead and 25% of learners working in groups gave the correct answers (c) Brass which is a combination of two metals while the others are simple metals. This was an improvement of 14.1% from 10.9% attained by students working alone.

Question 52 asks which one of the five was least like the other four if “Belt is to buckle as shoe is to (a) Sock (b) Toe (c) Foot (d) Lace (e) Sole”. The correct answer (d) “Lace” was chosen by 41.7% of learners working in teams an improvement of 23.5% from 18.2% for those working alone.

Question 53 asked whether the statement "If all Wargs are Twerps and no Twerps are Gollums, then no Gollums are definitely Wargs" is (a) True (b) False or (c) Neither. Again, (a) “True” was the answer as the assumption can definitely be made. Learners working in groups had 50% while those working individually scored 23.7%, an improvement of 26.3%.

Question 54 asked for comparisons to be made by asking “Which one of the five makes the best comparison” to “Finger is to hand as leaf is to (a) Tree (b) Branch (c) Blossom (d) Twig (e) Bark”. There was an improvement of 22.4% with students working in groups getting a low 33.3% for selecting the right answer (d) “Twig”. A leave is attached to a twig as a finger is attached to a hand. Learners working alone got 10.9%.
Question 55 wanted to find out how many trips to the store did John have to make to collect 9 cans of peaches if he could only carry 2 cans at a time: (a) 4 (b) 4½ (c) 5 (d) ½ (e) 6. The correct answer was (c) chosen by 58.3% of students working in groups an improvement of 31% from 27.3% of those working alone.

Question 56 wanted to find out how many students competed if Zola was 13th highest and 13th lowest in a spelling contest: (a) 13 (b) 25 (c) 26 (d) 27 (e) 28. The correct answer (b) “25” was chosen by 41.7% of team players. This increased by 34.4% on the 7.3% averaged by those working alone. There were 12 students lower and 12 higher plus Zola is 25.

Question 57 tried to find out which one of the five was least like the other four? (a) Ham (b) Liver (c) Salmon (d) Pork (e) Beef. The correct answer was (c) “Salmon” a fish and others were

meats. The score of 83.3% learners working in groups got was an improvement of 15.9% from 67.4% by those working alone.

Question 58 wanted to find out if the statement “If all Fleeps are Sloops and all Sloops are Loopies, then all Fleeps are definitely Loopies" is (a) True (b) False or (c) Neither”. The correct answer was (a) “True”. Those participants working in teams got 66.7% an improvement of 25.7% from 41% averaged by those working alone.

Question 59 deals with measurements and asked which one of the five, (a) CM, (b) Kilometre, (c) Acre, (d) Metre, (e) Millimetre is least like the other four. The right answer (c) “acre” denoted area while others referred to distance. Learners working alone scored 85.6% which is 2.3% better than those working in teams with 83.3%.

Question 60 tried to discover which three coins Sipho received after a purchase from the supermarket where he was given a change of R0.41 made up of six coins (a) Cents, (b) Five cents, (c) Ten cents, (d) Twenty cents (e) Fifty cents. The correct answer was (c) “Ten cents” because 3 ten cents, 2 five cents, and 1 cent is the only possible solution. Learners working in groups got 75% and those working alone averaged 31% an improvement of 44%.

7.8.5.3. Communication Skills

In this section the communication skills were assessed to ascertain whether by playing in groups and answering question in groups helped to improve English proficiency of learners. Learners who played *γKhozi* in groups averaged 77.1% an increase of 38.7% from those who participated individually with the mean of 38.4%.

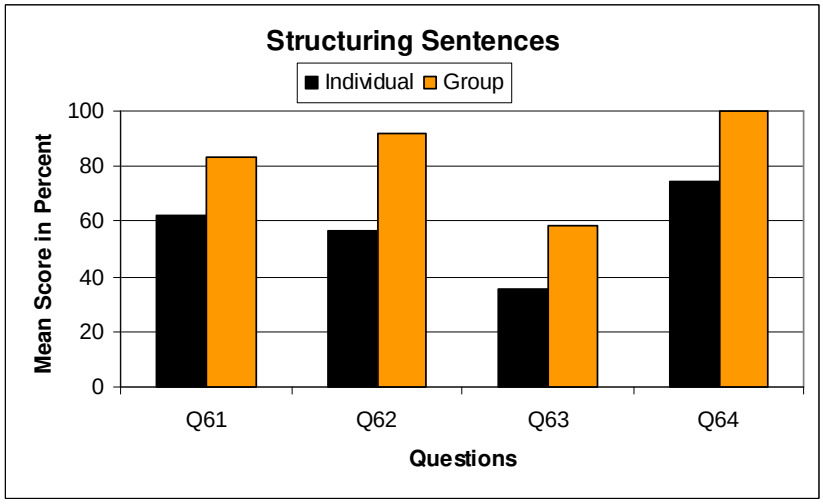

Figure 7.19: Results on skills to restructure sentences.

Structuring Sentences Assessment

This section was designed to measure the ability of learners to recognize language that is appropriate for standard written English. Learners working in groups showed a great improvement of 26.2% with the achievement of 83.3% from 57.1% previously achieved by students working alone (Fig. 7.19).

For question 61, learners were asked to insert into blank space (a) "retards" in order to form a sentence "Refrigerating meats retards the spread of bacteria". The correct answered was given by 83.3% of learners working in groups, an improvement of 21.4% from 61.9% for learners working alone.

Question 62 needed learners to choose (b) to form a sentence "Throughout the animal kingdom, 'only the whale is' bigger than the elephant. The correct answer was chosen by 91.7% of participants working in groups. This was an improvement of 34.9% for learners working alone who averaged 56.8%.

For question 63 majority of students (58.3%) working in groups chose the correct answer (b) which helped to construct the sentence, "The fact 'that' money orders can usually be easily cashed has made them a popular form of payment". This was an improvement of 23% from 35.3% from students working alone. Again, 33.3% of those working in groups selected the wrong answer (c).

For question 64 learners were supposed to form the sentence "The constitution of South Africa gives parliament 'the power' to pass laws". All learners who participated in groups chose the right answer (a) and this was an improvement of 25.5% from the average 74.5% for those learners working alone.

Written Expressions Assessment

The following section, just like the previous section, was designed to measure learners' ability to recognise language that is appropriate for standard written English. The mean score of 70.8% attained by learners who played *γKhozi* in groups again saw a marked improvement of 35.9% from 34.9% attained previously by learners from Buhlebemfundo working in groups (Fig. 7.20).

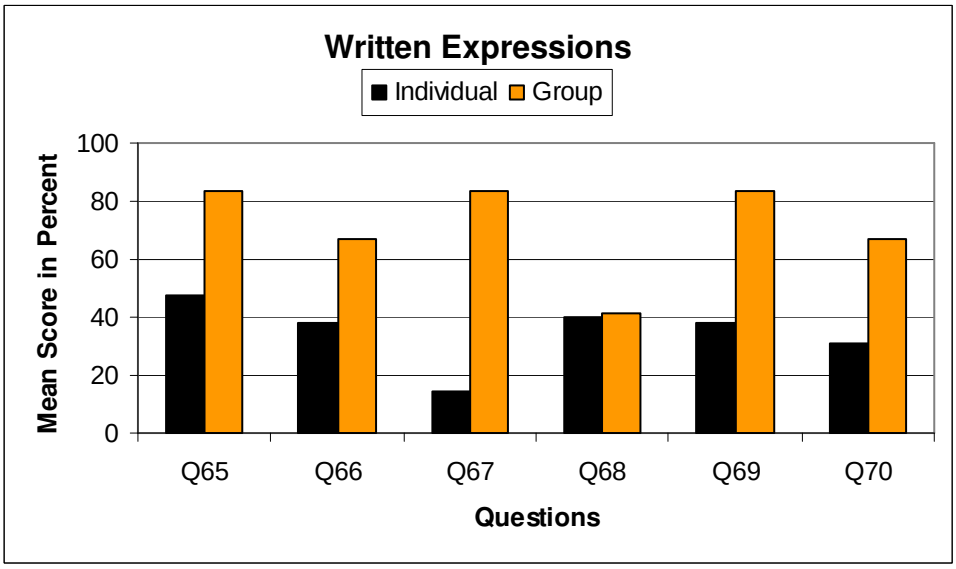

Figure 7.20: Results on written expressions.

For question 65, learners were supposed to choose the correct answer (c) "with" as it was the word which made the expression wrong. The mean of 83.3% for learners working in groups was an improvement of 36% with students working alone averaging 47.3%.

For question 66 the correct answer was (a) "identification" as it made the expression to be wrong. Performance for all students working in groups was 66.7% an improvement of 28.5% from 38.2% attained by learners working alone. A quarter (25%) of learners working in groups chose the wrong answer (b) "believed".

For question 67 there was a huge improvement from 14.6% for students working on their own to 83.3% those working in groups, which is an improvement of 68.7%. Learners could not recognize that the word making the expression wrong was (a) "deficient".

For question 68, (c) "foot" was the word that made the sentence to be incorrect as there was inconsistency of numbers. Learners making 50% chose the incorrect answer (b) "its". There was not much difference between 41.7% for learners working in groups and 40.1% for those working alone, who gave the correct answer.

For question 69, learners working in groups averaged 83.3% outscoring those working alone by 45.1% as they had obtained the low mark of 38.2%. Almost 40% of learners pluralized the name Mark Shuttleworth by choosing (d) "them" which made the sentence incorrect.

For question 70, two thirds of learners (66.7%) working in teams realised that the correct answer was (d) "more large" and was grammatically incorrect. The improvement was 35.7% from 31% achieved by students working individually. The results show that learners were able to assist each other and determine if English expression were well written or not.

Reading Comprehension Assessment

In this section the assessment was on learners' ability to read and understand short passages similar in topic and style to those found in tertiary institutions. Again the mean score of 63.4% attained by learners working in groups is 30.4% higher than the 33% previously averaged by individuals from Buhlebemfundo (Fig. 7.21).

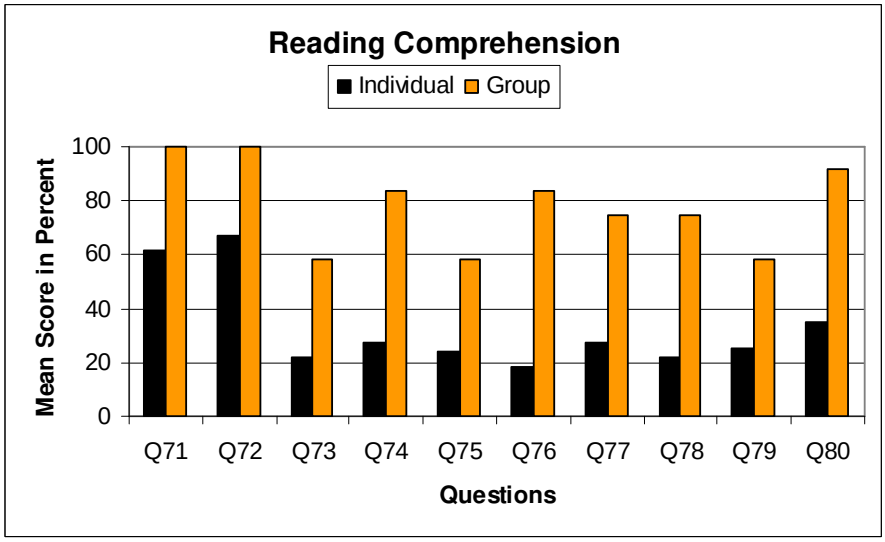

Figure 7.21: Results on reading comprehension.

Question 71 tried to ascertain if learners understood the core of the passage and 100% of learners working in groups selected the correct answer (b) "Kenyan politics". This was an improvement of 38.1% for those working in teams from 61.9% of students working alone.

Question 72 tried to determine what "the word 'they' in line 2" referred to and 100% of learners working in teams choose the correct answer (c) "John and Charles", an improvement of 32.6% as those working alone had 67.4%.

For question 73 only 58.3% of students had the correct answered (d) "appealing" as it was looking for the word closest in meaning to "charismatic" and this was an improvement of 36.4%. The means was low at 21.9% for learners working individually.

Question 74 tried to discover what the two men enjoyed and the answer was (a) “the buzz of the city” achieved by 83.3% of students working in groups an improvement of 34.6% from 34.6% for those working alone.

On the other hand, learners gave wrong answers where questions needed to infer meaning from the passage and a deeper level of thinking expected. Question 75 asked which phrase had the closest meaning to “bumming around” and the correct answer (b) “sitting down and doing nothing” was chosen by 58.3% of the learners working in groups and 23.7% of those working alone. This was an improvement of 34.6%. Here 25% of learners working in groups chose the wrong answer (a) “running from place to place” even though the passage stated that the two had lost their jobs and were no longer doing anything.

Question 76 asked learners to choose the statement which the author mentioned as not important in order to change society. There was a huge difference of 65.1% between students working in groups who averaged 83.3% and those working alone who had 18.2%. The correct answer was (b) “fast talking politicians”.

Question 77 asked students what John and Charles joined. The passage explicitly stated that they joined (d) “one of the opposition parties” and only 27.3% of students working alone selected the correct answer compared to 75% of those working in groups, an improvement of 47.7%.

Question 78 asked which phrase meant change brought about by the ordinary people and only 21.9% of learners working individually gave the correct answer (a) “change taking place from grassroots level upward” compared to 75% of those working in teams, an improvement of 53.1%.

Question 79 asked which phrase had the closest meaning to “was out the door” and the correct answer (a) “leaving” was chosen by 25.5% of students working alone Learners working in groups attained 58.3% and improvement of 32.8%. A Quarter of participants (25%) chose the incorrect answer (b) “kicking out the door”.

Question 80 wanted learners to point in the passage where it showed that the bus had problems, and 91.7% of all learners working in groups chose the correct answer (c) “line 31” which states that the bus had a flat tyre. This was an improvement of 57.1% from 34.6% chosen by those working alone.

Visually comparing participant skills using the Persona Outlining Model it is obvious that those participants who played in teams out-persofmed those who were not part of a group (Fig. 7.22). However, both groups lack folding (2D to 3D visualisation) and numeric skills. Cooperation and game play appeared to influence 2D and 3D visualisation, reading and writing skills.

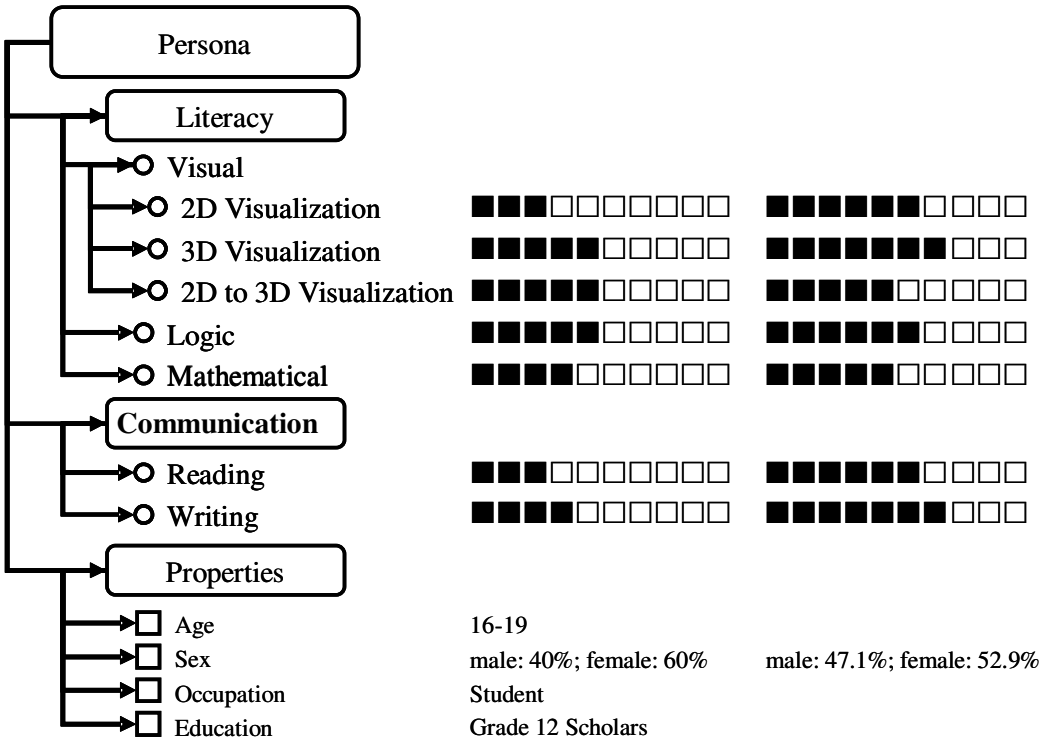

Figure 7.22: Comparison of skills of student working on their own (Collumn 1 n=51) and those working in groups (n=55) shown using the Persona Outlining Model.

7.8.6. Reflection and Discussion

The findings of this part of the study illustrate that *γKhozi*, a game developed on modern educational principles (GOM) and played by groups of learners who were encouraged to discuss their problems and game-play, appeared to effectively enhance student performance and promoted their learning skills. Through the researcher's interaction and observation of the learners during game play, the importance of a facilitator was highlighted. These games need subject specialist such as teachers, who should act as facilitators, to provide guidance and clarity during play as learners' knowledge is enriched. Learning devices such as games, therefore, do not replace the role of teachers but realign it to meet the challenges of a new form of a teacher who is no longer a source of all knowledge but some one who recognises the wealth of knowledge learners bring with them to school (Seagram, 2004). Becta (2004) asserts, "Simply

putting children into groups does not generate co-operative learning. …Significant teacher support is necessary if 'games in classrooms' is going to be viable - in the areas of using the game paradigm, and in using and managing the technology". The role of teachers within this social constructivist paradigm needs to be changed to that of a facilitator and not of the source of all knowledge. During game play the learners encountered problems which could only be solved with some assistance from the facilitator without giving them the answers.

This finding support the ideas of Vygotsky (1978) where he wrote that the zone of proximal development is "the distance between the actual developmental level as determined by independent problem solving and the level of de-development as determined through problem solving under adult guidance or in collaboration with more capable peers".

Since its inception in 2001 GOM, a conceptual model which combines game design and educational theory (2001), has gone through many changes. The latest change was the addition by Seagram (2004) to the Problems component of two concrete interfaces of *Content* and *Interface design*. This research proposes to include another concrete interface, that of *Social dialogue,* to the Problems component. It was through engaging with *γKhozi* that players were able to work in groups and through *social dialogue*, they were able to solve the problems presented during game-play and the skills evaluation instrument. Such environments appear to offer learners who might struggle in the traditional learning environments a unique opportunity to engage with other learners. Therefore, the GOM needs to be extended through the pertinent inclusion of collaborative environment, which facilitates the ever increasingly important aspect of *social dialogue.*

The idea that technology mediated learning can improve performance if administered carefully is supported by, among others, Zhang and Peck (2003), who used multimedia tools in their research and found that there was a significant difference between learners working in groups and those working alone. They also reported that learners appreciated and enjoyed collaborative learning as long as they felt that their ability to communicate was unhindered by technology. Breuleux and Silva (1994) discovered that students accept technology when it is introduced in a more participatory manner. In addition, interactions among students have proven to produce positive learning outcomes (Brown *et al*., 1986).

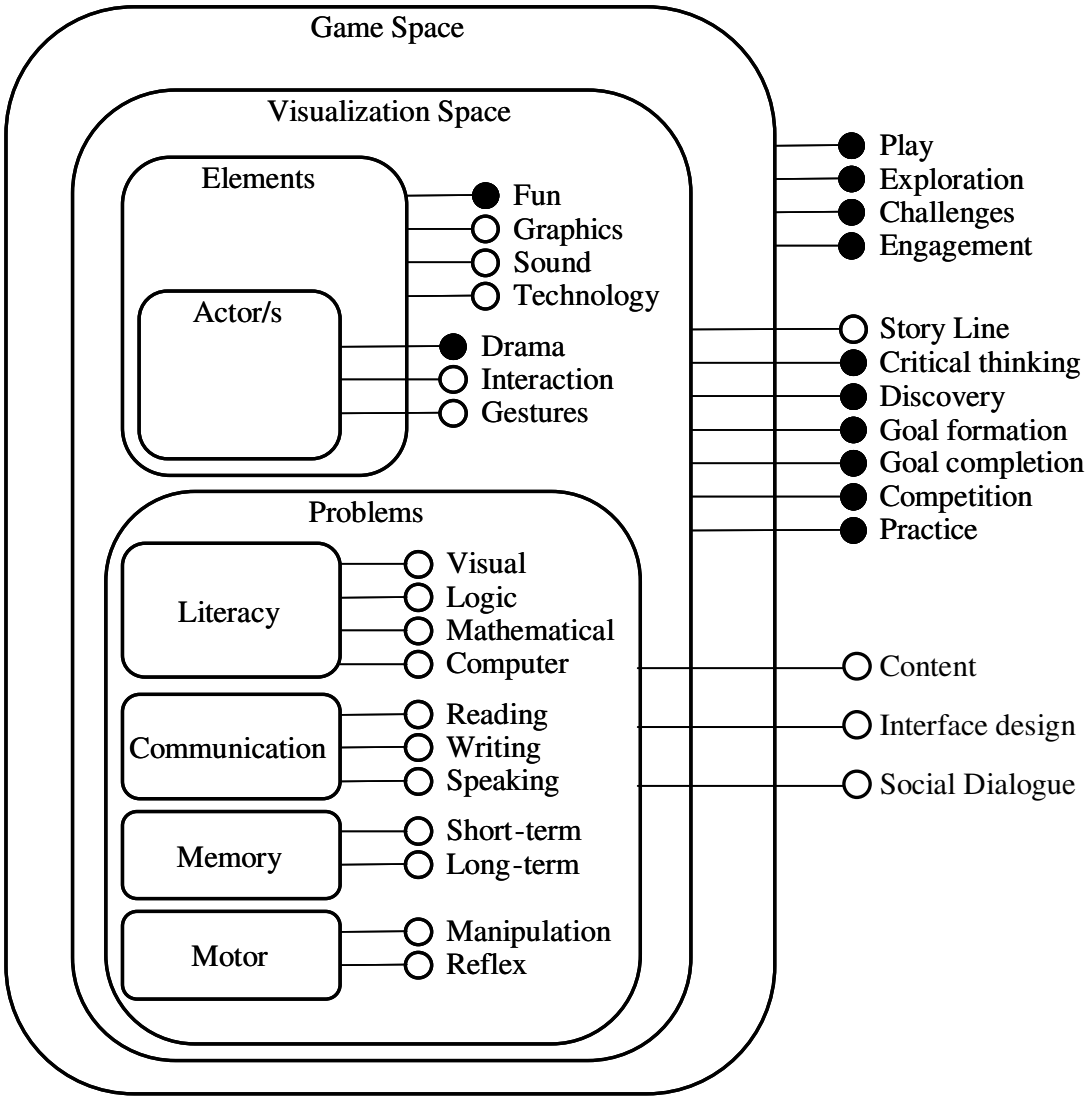

Figure 7.23: Representation of the revised GOM which includes the Content interface and Interface design as promulgated by Seagram (2004) and the new *Social dialogue* interface.

While playing *γKhozi* participants were able to set their own pace, make mistakes, seek clarity from their peers, deal with group conflict, make decision, doubt those decision and revisit them as many times as they liked. Bowman (1994) argues that traditional schools do not accommodate the different ways, beliefs, cultural expression and norms of the poor and of the minority groups and states that this hinders progress of such groups and limits the ability of teachers to educate them. The results clearly highlight the importance of embracing cultural and social interaction as these assist in enhancing performance of learners even of those who come from the disadvantaged backgrounds.

Playing *γKhozi* in groups significantly improved communication skills (77.1% versus 38.4%, Wilcox Signed-Rank test $p < 0.001$, Significance Test $Z=-8.063$) although participants were

mainly isiZulu speakers who struggled with spoken English. An interesting observation made regarding the way communication took place between learners, during play and when answering the questionnaires, was that most expressed themselves and explained things by using a mixture of English and Zulu. This supports the idea that this type of discourse embraces the learners' cultural ways of interrogating and solving practical problems. Cairney (1999) found that because traditional school structures in Australia were not able to cater for a multicultural society, teachers struggled daily with how to acknowledge and build on the languages and cultural diversity of their classrooms. Within the context of South Africa, the problem of an education system not taking cognisance of its multicultural environment is highlighted by Webb (2002) who advocates the use of African languages as one of the languages of instruction in schools. Webb argues that in a multicultural society like South Africa the English language proficiency required for effective educational development is generally not present and difficult to acquire among black learners given the sociolinguistic context of South Africa. Puro and Bloome (1987) suggest that the importance of communication in instruction is often overlooked although it had powerful effects on what children learn in school.

With regard to the visualisation skills, students working in groups had the mean score of 60.8% an improvement of 14.1% from that of 46.7% for those learners working alone. In order to verify the results, the Wilcox Signed-Rank test, which detects the differences in the distributions of two related variables, was chosen because of the small size of one of the samples. The Sign Test gave a small significance difference of $p < 0.001$, which suggests that performance for the two groups was different. This also confirms that learners playing *γKhozi* in groups outperformed those working alone with a difference of Z=-7.819. It is argued that visual representations are useful to students with non-traditional learning styles and that students learn best when information is provided in their preferred learning style (Riding and Grimley, 1999).

The results on numeracy show that after playing *γKhozi* and working in groups learners performed better in mathematical skills by attained a score of 55.8% compared to 30.9% achieved by those who did not participate in the game. The Wilcox Signed-Rank test gave a significance difference of $p < 0.001$ indicating that performance by the two groups was statistically different. The Sign Test results of Z=-8.064 was in favour of learners working in groups. The problem of learners with lack of numerical skills does not only exist in South Africa but it is a global phenomenon. Bowman (1994) found that in the United States of America, the African-Americans and students from low socio-economic backgrounds do not have skills to participate in the social and economic life of their country as they constantly perform below the national average in mathematics and language skills. However, Moore

(2002) who carried out a research at the University of Cincinnati concluded that African-American male learners, who were the lowest performers in mathematics, found that working together in groups helped to improve their academic performance.

7.9. CONCLUSION

The objectives of this part of the study were to investigate the use of educational tools to address specific learning objectives in urban and semi-urban areas. Amory (2001) argued that solving puzzles while playing educational games could play an important role in learning. However, participants in this study did not develop a better understanding of photosynthesis and respiration when they played *Zadarh*, an educational game specifically designed to challenge specific misconception related to photosynthesis and respiration. Careful examination of this finding suggested that while participants appeared to advance through the game, they were not solving the problems themselves but reverted to the predominant mode of learning (rote). Also, it was not clear if the use of an English-language test instrument did not negatively impact on the performance of those participants whose home language was not English. To test these suppositions, participants played *Zadarh* in groups where they were encouraged to discuss their problems during game-play and some of them also were allowed to ask for explanations to questions in the test instrument they did not understand. Results from this part of the study strongly support the argument that learning is a social activity and only through dialogue can misconceptions be overcome (Vygotsky, 1978).

A number of skills are required in order to gain access to and to succeed at tertiary education qualifications. After evaluating the different learning skills in Chapter 3, it was found that many semi-rural participants were poorly prepared to enter tertiary education as they lacked the necessary skills. However, educational games were developed and used which tried to improve some of the basic skills such as literacy and communication and cognitive skills, in order to answer the question whether the use of games based on sound educational concepts and theories be used in developing a number of skills? In order to answer this question an investigation was carried out where participants played in groups an educational adventure game, yKhozi, developed to teach players about diseases including Cancer, tuberculosis, malaria and HIV/AIDS. They learned about these diseases while they were improving the aforementioned skills. The results presented in this chapter clearly illustrated that play8ing games was not only entertaining but also participants managed to improve their knowledge regarding the diseases but also and most importantly, their literacy and communication skills improved. Therefore, the study revealed that properly designed microworld games are an effective way of teaching and learning and can be used to develop cognitive and many other skills.

CHAPTER 8
CONCLUSION AND RECOMMENDATIONS

8.1. CONCLUSIONS

Nearly 12 years after the new South African democratic dispensation the social and economic dynamics have not changed much with most Black South Africans still attending schools in the townships, rural and semi-rural areas where the education offered appears not to have changed to any extent. Learners are still underprepared for a tertiary education and for the labour market. The results presented here clearly indicate that the use of suitable learning games, especially those based on appropriate learning theories, are most important to the learners who come from the rural and urban communities.

While the hype about the effectiveness of virtual learning environments, which include computer games, is well articulated in many academic papers and journals, many such environments are neither based on any proven theoretical underpinnings nor on research findings. Developing interactive games like *γKhozi* is a challenge to educationists who try to discover new ways of solving educational problems such as those faced on a daily basis by the majority of learners in South Africa, who are educationally, socially and economically disadvantaged and are often products of instructivist methods of teaching. Research presented here makes use of interactive games grounded in appropriate learning theories and design principles to solve particular learning problems associated with developmental problems found within the South African educational system.

Many problems in South Africa appear to be a direct result of the educational system (past and present) which do not address the needs and the aspirations of the people. The educational systems have affected people's social life, their earning potential and their learning ways. In 2005, the educational system does not provide learners with cognitive and critical skills to be competent members of tertiary education. The government's endeavours to provide education that empowers learners to be future players in the economy seem to be in vain with little improvement in learners' skills. Again, in 2005, a high school graduate is no better off than in 1994 at attainment of the democratic status. Today, evident in the society are problems of lack of skilled labour, of a widening gap between those who are affluent and their poor counterparts and of a good education for those affluent Blacks and majority of Whites, to the exclusion of the majority of the disadvantaged groups. Schools in townships and semi-urban areas and previously Blacks-only universities still provide incomparable education to that of their counterparts from the previously Whites-only tertiary institutions.

The use of the Persona Outlining Model (POM), which uses real data, to measure skills a typical South African learner brings to tertiary schools indicate that this learner arrives at the university for the first time with little literacy and communication skills, insufficient to assist them to cope with the demands of their new academic life. The study reveals that most learners lack literacy (visualisation, logical, and numerical) and communication (reading and writing) skills. The township and semi-rural schools and previously black-only universities produce and admit, respectively, learners who lack necessary skills for tertiary learning. Thus, performance is directly related to race, language of instruction and economic status of the individual.

A Persona quantified according to the POM indicates that a typical South African learner needs to improve their mathematical, 2-D visualisation, 2-D to 3-D visualisation, logical and reading skills. It appears that rural and township community schools do not equip learners with literacy and communication skills necessary to participate fully in society

The findings show that performance in the classroom is directly related to at least: (i) race, (ii) socio-economic status, and (iii) parents' educational status. In the context of South Africa race and socio-economic status are directly attributable to the apartheid past,, consequently Black learners who are mainly from low socio-economic environments, townships and rural and semi-rural areas, performed poorly while their White counterparts who are generally from a higher economic bracket and their rich Black peers performed with distinction. Learners from affluent backgrounds, black or white, perform better than those who come from poor black or white households. Indications are that affluence is also directly positively related to educational achievement, that is, literacy and communications skills develop with the increase in social and economic affluence of the people.

The educational level of parents has a direct effect on the performance of learners, with the gap widening as the parents' level of education increases. The study discovered that students who come from families with low levels of education do not perform as well as those who originate from families with at least one of the parents having a tertiary education. Again, most Black learners have poor literacy and communication results as they come from families where none of the parents had a high school certificate

The study found that home language and performance are directly related with the English language speakers performing better than isiZulu speakers in all the different skills categories. The literacy and communication skills are also related to the home language, with learners whose home language is not English perform worse than those who speak the language more

regularly. This research found that the South African education system favours more the white learners and those affluent Blacks who schooled in the previously Whites only schools. This means that the socio-economic status of the majority of learners from the rural and township community school is less likely to improve as most of these learners lack the basic skills to get university entrance.

Another important aspect of the South African education systems (past and present) is that, although in terms of performance there is a conspicuous racial gap influenced by language and economics status among others, there is no indication of any gender difference on performance. The research found that gender plays little role in the performance of learners. Although, male learners performed slightly better than their female peers in both the literacy and communication, the results were not statistically different meaning that gender and performance are not related.

The findings reveal that township and rural schools do not provide learners with good visualisation skills. These learners are only competent to deal with 3D visualisation skills while they are not skilled to work with 2D objects and to manipulate and change 2D to 3D objects. In general, the results also demonstrated that the skills levels were the same for the two genders.

Regarding the logical skills and numeraical skills, the results indicate that products of South African community schools enter tertiary schools with minimal proficiency on these skills. The learners from the community schools lack the mathematical skills, which are demonstrated to be directly related to the logical skills.

Most learners who graduate from schools are not able to articulate themselves well in English, they are, however, better off in reading than in writing. The results show that learners could not determine if sentences are structurally well written and this signified the learners' inability to communicate in English by the time they reach tertiary level.

Although, most learners could play the game they lacked the cognitive skills to relate the questions to the game played. This means that most learners are not able to explain the concepts and confuse the relationship between photosynthesis and respiration and times of their occurrence.

Once the levels of literacy and communication were determined, the two microworlds games *Zadarh* and *yKhozi* were also used to confirm that what Rieber (1996) stated that interactive

games could enhance learning and develop cognitive skills and motivation. In addition, the study intended to contribute meaningfully to the development of theory in teaching and learning.

After learners from the community schools had played Zadarh, the results indicate that there were still some problems. A study initiated by Adams (1998) found that learners confused the relationship between photosynthesis and respiration and considered these processes to be opposites. Adams' study was revisited with the intention of ascertaining the effect if learners used a more interactive game than *Zadarh* to study the same phenomena. When learners played *Zadarh* alone it was found that after long hours playing the majority of them still harboured misconceptions relating to photosynthesis and respiration. This indicates that misconceptions are not overcome by simply playing an educational game designed with constructivist notions in mind as learners inadvertently tended to revert to their predominant mode of learning, which is rote, and they played from memory. It was observed that rote learning took precedent as learners always tried to retrace their steps to reach positions they previously reached in their previous play without much thinking and they are not be able to explain how they reached their answers. Learner using rote learning tended to confuse the two concepts as they also confusing the rooms within the game because of not reading and being observant enough, hence not realising where they were in the game.

The second round of game playing where learners worked in groups was initiated. Learners played *Zadarh* in groups and their improved results indicated that learners perform better when playing in groups compared to those who worked individually. The results uncovered that cooperation between people with a common goal yields better results than individualism. Even the results of learners who are generally poor performers improved once they worked collaboratively. The findings indicate that well designed adventure games used collaboratively are effective learning tools.

After playing the *Zadarh* in groups the results showed drastic improvement, however, those learners who worked in groups and took oral tests performed even better than those who took the written paper. This proved that by understanding well what is required enhances performance. This finding supports the importance of dialogue and the sharing of ideas and experiences in an educational setting. Although, learners working in groups still harboured certain misconceptions, the results of those taking the oral test were even better than those doing the written test which suggests that some learners did not understand the test instrument and that the understanding of written language can influence outcomes. What this meant is that by

playing games while interacting with other learners improved the proficiency of learners on the topic presented to them.

In a group learning environment where problems were discussed learners were able to overcome their misconceptions. The results demonstrate that for effective learning to take place students have to engage in a social constructivism which fosters problem solving and prevents students using their preferred learning style of rote learning. Thus, dialogue is paramount in learning as without it learning is curtailed. This again proves that learning is both a social.

A follow up study was carried out where *γKhozi,* an adventure game developed on modern educational principles (GOM), was effective in enhancing student performance and promoted learning skills when players were able to work in groups and used *social dialogue* to solve the problems presented during game-play and the skills evaluation instrument. The success of *yKhozi* stems from its inclusion of dialogue and interaction, cooperation and assistance from others, including the researcher. *yKhozi* was successful in incorporating the main pillars of OBE attributes, namely that: (i) All students have different ways of learning and can successfully learn not on the same day or same time. The game allowed learners to play it at their own time when computers were free; (ii) Successful learning promotes even more successful learning, i.e. where learners who grasped the concepts study quicker were able to pass on the new found knowledge to their peersp; and (iii) Schools have to liberalise the conditions of learning so that both learners and teachers can contribute meaningfully to successful learning. All these contributed to better outcomes of this part of the study.

The play of *γKhozi* allowed learners from diverse backgrounds to come together and solve problems through teamwork and dialogue. It must be stated that although *γKhozi* portal provided players with knowledge related to viruses and bacteria, HIV/AIDS, and Cancer and tuberculosis, other important skills (visualization, communication) were learned through solving of puzzles. The initial results, based on the POM, indicate that learner skills are inadequate for studying at tertiary level but after playing yKhozi the POM instrument results suggests that participants, who play as a member of a team, had mastered a number of skills not directly related to the game challenges themselves. The *γKhozi* environment provides a social space for cross-cultural interactions, where all ideas are considered important, irrespective of their point of origin. Thus, playing *γKhozi* also permitted the players to gain some insights into the educational content (diseases) that they thought was enjoyable and motivating while improving their literacy and communication skills.

The research, therefore, extended the Problems component of GOM by introducing the concept of *Social Dialogue*. It was the discovery of this research that working in teams will yield some improvements, however, huge improvement is certain if dialogue is the central part of teamwork. In an endeavour to achieve the common understanding of concepts through working in teams, learners who might have struggled had the opportunity to query other learners and verbalise their opinions. It is through interacting with each other that dialogue can be promoted and meaningful contribution is made to learning. Because of the centrality of dialogue to social constructivist learning methods, students working in teams performed better than those working individually. This led to the finding that computer games are effective learning tools if designed to promote and inculcate social interactions and dialogue among learners and between learners and teachers.

The use of adventure games, such as *yKhozi* allow learners to form their own communities of learners, through social networks, to come together and strive for a common goal. The benefits for these social networks were the improved results. Therefore, there is a need for change in the educational system enough to discourage rote learning and to promote social networks and social constructivist learning methods. Games such as *yKhozi* are a good example of such learning methods in practice.

It is interesting to note that the educational implication highlighted by Vygotsky (1978) that include the interaction between learning and development (Zone of Proximal Development), the role of play in development ("Though the play-development relationship can be compared to the instruction-development, play provides a much wider background for changes in needs and consciousness") and the need for written language ("as a result of mastery of written language and the ability to read – and of thus becoming aware of everything that human genius has created") are just as pertinent today as they were nearly 80 years ago. Thus, the new art form of digital games, conceived as adventure, can play an important role in education if they support cooperation between players, peers and mentors, allow for exploration through play and support the development of reading and writing skills.

The role of teachers needs to be emphasised as without their proper guidance learning becomes handicapped. The results improved where guidance was provided, whether in the form of interpretation of the questions in the oral tests or just in queryieng learners who became puzzled while playing the game or even by mere suggestion of how other people might tackle the problem encountered. The improvement supports Vygotsky's (1978) findings who suggested that learning environments should involve guided interaction, permitting children to reflect on

inconsistency and to change their conceptions not only through Piaget's intelligent action but also through speech and communication. This is what Vygotsky meant when talking about the concept of a learning environment consisting not only of children and learning material and processes, but children, learning material and interactive communication.

The study reveals that learners from the disadvantaged communities can benefit a great deal from properly designed adventure games that accommodate their cultural differences, experiences and languages while promoting dialogue. Dialogue needs to be a central feature of such games because without it, as the study has indicated, there is very little improvement in the skills development.

There is a need to introduce this type of games to community schools learners, who are by their nature disadvantaged. The games can assist them to overcome their underpreparedness status by improving their cognitive abilities and literacy and communication skills, through solving of puzzles and talking to their mates. These games could assist learners to continue with their studies even in the absence of teachers, and depending on their design, learners could post their queries at any time or have them ready for their next meeting with their teacher or their peers.

In conclusion, it is important to note the two major findings. Not all games can be effectively used in learning for the enhancement of learners' skills and other general performance as even properly designed games cannot enhance learning effectively if there is not sufficient provision of guidance to learners from teachers and a social environment is not created where learners could work together in teams or groups so that they can learn together and from each other. The research established that learning is a social activity dependent on dialogue. Therefore, the findings of this research are that the major cornerstones of learning are teamwork and *social dialogue* and it is through them that the learning goals are attained.

8.2. STUDY WEAKENESSES

In the study, a number of problems were encountered which may have influenced the study and include:

(1) The lack, or different level of, computer literacy. While the two games used in this study require only mouse action to navigate successfully through the virtual games environments, groups varied in their computer skills and their innate understanding of the game environments. Participants, especially those from disadvantaged schools, consequently spent the initial contact sessions learning to use a mouse and learning game navigation metaphors.

(2) Access to suitable computer technology. Most of the schools lack appropriate computers to run the game software. Consequently, participants were transported to UKZN and therefore participants had limited access to the learning resources. In addition, in one case the teacher associated with one group, while wishing to participate in the project, attempted to exert control over the research process that required the participates to be transported to UKZN to overcome this problem

(3) Use of outdated pedagogical practices in schools. It appears that despite the introduction of the Curriculum 2005 and Outcome Based Education, most learners expect to be told what to do and are therefore more likely to undertake tasks just to complete them without sufficient exploration or understanding

(4) Need for sustained and longitudinal studies. One of the most complex research problems associated with the influence of appropriate learning games on education processes and outcomes is the requirement of sustained interaction with participants over a long period of time that is often difficult to manage and conflicts with classroom demands. Also, the use of instruction as the predominant educational pedagogy in many schools, especially those in disadvantaged areas, negates the introduction of such learning tools as games without apt staff development in the use of such tools in the classroom.

8.3. RECOMMENDATIONS

The level of students' under-preparedness to study at tertiary levels appears to suggest that the educational system has not yet considered the cultural, social and economical conditions of the majority of South Africans learners. Therefore, there is a need for:

(1) A new approach to primary and high school curriculum. This has to be inclusive and enhance visualisation, logical, numerical and communication skills. For example, it is established here that visualisation skills, such as pattern matching or transforming 2D planes to 3D objects are related to logical skills, thus, including them in the curriculum can have a positive effect on learners' cognitive abilities.

(2) The introduction of a social constructivist curriculum founded on dialogue, collaboration, and acceptance and tolerance of cultural differences. In a multiracial society, embracing these differences is of vital importance. This is because for learners to overcome their deficiencies they need an educational environment which accommodates each learner as unique individual who has something to offer to others as well as receiving from them.

(3) An educational system that promotes the development of social capital through the inclusion of interaction, participation and dialogue. This attainment of this is through the building of networks of learners who will work together for the benefit of all.

(4) There is a need for the development of appropriate language skills. Language was found to be one of the major contributing factors to the problem of underpreparedness when learners are forced to study in a foreign language. It is therefore, necessary for curriculum developers to emphasis the need for proficiency in the English language from the early stages of learning as this contributes to the development of other skills such as logic and visualisation.

(5) Investing in networked computers (connected to the Internet) capable of supporting asynchronous and synchronous teaching and learning. Again, the amount of information available on the Internet compels institutions to install this technology on their campuses as a matter of urgency. The Internet opens up spaces for social capital to occur, where learners from across the globe can come together, form their networks and share their experiences in order to attain a common goal.

(6) Introducing full multimedia games such as *γKhozi,* based on social constructivist principles, allowing collaboration and development of social networks among learners as appropriate learning tools. The government and schools need to understand that education is a partnership between many people, who might have differing agendas but who still need to work together. Consequently, there is a need to introduce games like *γKhozi*, which could provide asynchronous and synchronous dialogue in the learning environment.

(7) Research on the use of ICT and games in the classroom within a South African context in order to foster an understanding of social constructivism. This could provide answers to whether the sharing of the social space created by the Internet could yield the same results as those learners who share the same computers and are able to do a face-to-face discussion.

While computer games are the digital realization of telling stories in a different way where computer technologies can be used to create virtual worlds that integrate communication devices, it is the learning theories that should inform educational practices. These theories assist instructional designers, some of whom might not be educators, to map out the exact path for designing and developing these games whilst ensuring that they know what are the expected outcomes of each game. It is the conclusion of this research that *social dialogue* and *social interaction* are important aspects of education and need to be incorporated in the curriculum.

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ANNEX 1

PART 1

Please answer all the questions below accurately and do not leave any question unanswered.

Directions: For Part 1 use spaces provided in this question paper and place your answers in the boxes associated with the questions. Where a cross is needed place that gross in the empty box following the answer you deem correct or the most approximate.

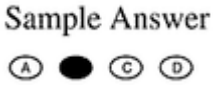
Example (a) Who is the president of South Africa?

Answer: is T. Mbeki
Therefore cross in the box after Mbeki's name.

Clinton		Mbeki	*X*

N.B. For **Part 2 up to Part 8** use the ANSWER SHEETS provided by filling the spaces so that the correct letters cannot be read.

For example, where the answer is B fill the space like in this sample answer.



Please answer questions below
(where necessary put a cross in the empty box following the answer you think is correct)

1. State your sex

Female		Male	

2. How many languages do you speak? ☐

3. What is your home (first) language? ☐

4. Which other languages do you speak?

5. How well do you speak these languages? (Please write the language in the appropriate column, For example, I can speak Sesotho fluently – Sesotho is therefore written under "Speak Fluently")

	Speak Fluently	Speaks it well	Cannot speak it well	Can understand **but** cannot speak it
e.g.	**Sesotho**			
1.				
2.				
3.				
4.				
5.				

6. How many brothers and sisters do you ☐ have?

7. How many of your brothers and sisters are at school? | |

8. How many of your brothers and sisters are at tertiary schools? | |

9. Do your parents/guardians support other people other than your direct family?

Yes		No	

10. Approximately how much is your household income per annum. (How much do you think is the combined salary of your family members).

Less than R15, 000		R15, 000 – 50,000		R50, 000 – 80,000		R80, 000 & above	

11. What is the highest level of education reached by members of your family?

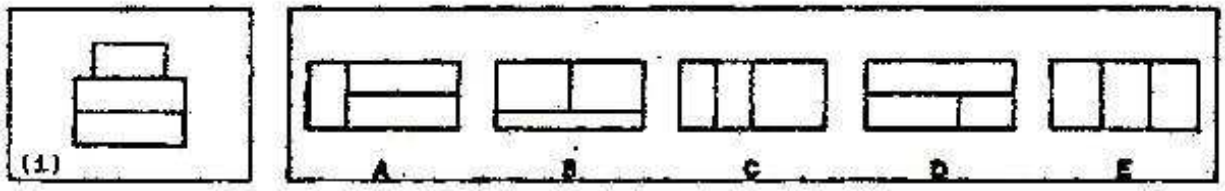
MOTHER/GUARDIAN	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Father/Guardian	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Sibling 1	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Sibling 2	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Sibling 3	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Sibling 4	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
Sibling 5	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	

WHICH OF THE FOLLOWING ITEMS DO YOU HAVE AT HOME?

Electricity	
Running water	
Car	
Fridge	
Microwave	
TV	
Cell phone	
Phone Telkom	
Computer	
Laptop	
Internet connection	

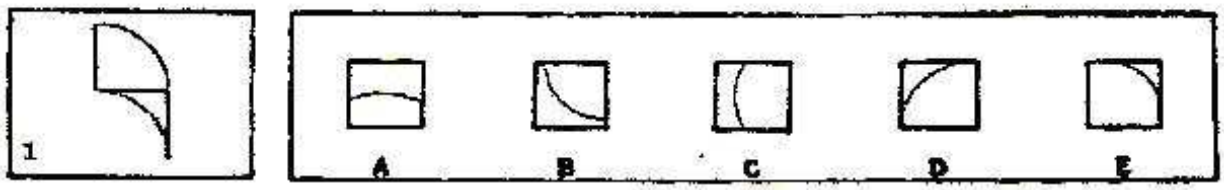
PART 2

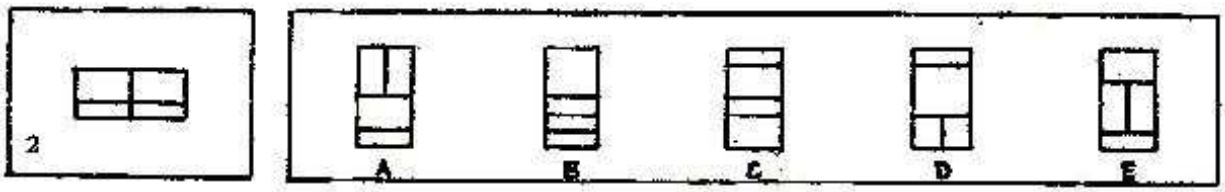
These are exercises in finding rearranged figures. Find the lettered figure which is made up of the same pieces as the numbered figure. Below is an example:

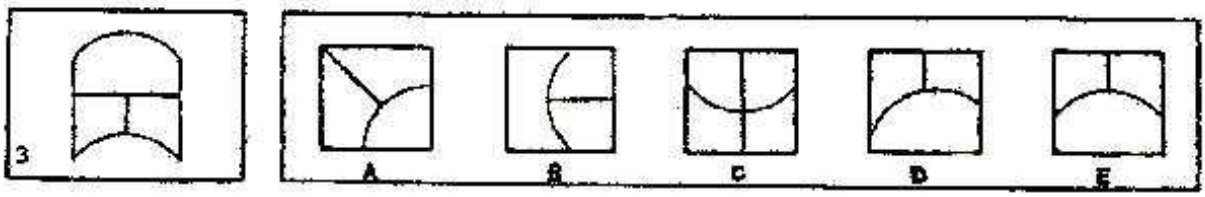


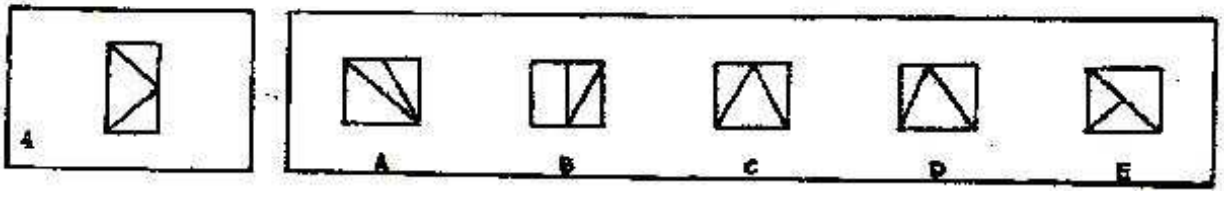
The correct answer is A since it is made up of the same pieces; 2 long pieces and 1 smaller piece. Therefore, cross out the letter A on the answer sheet next to question (i).

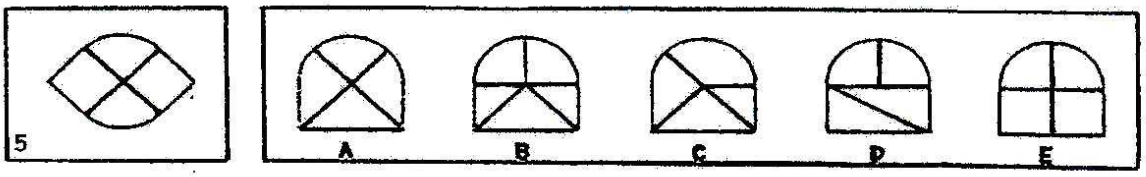
Answer the following:

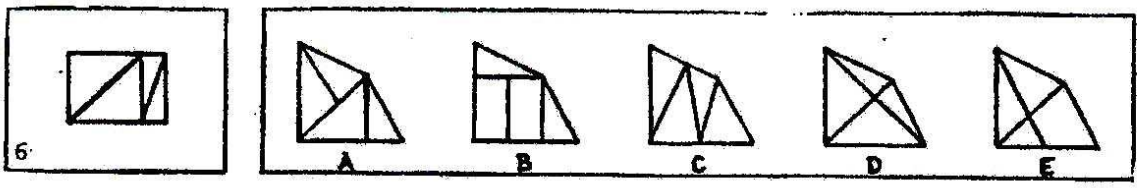


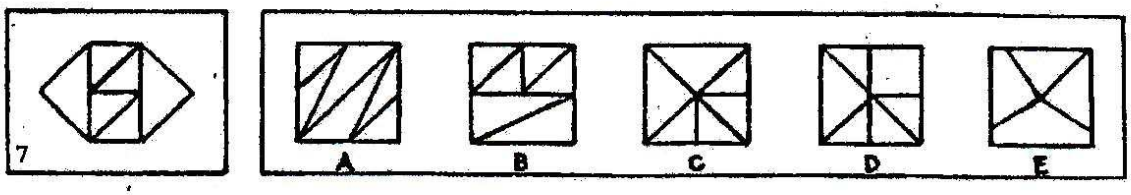


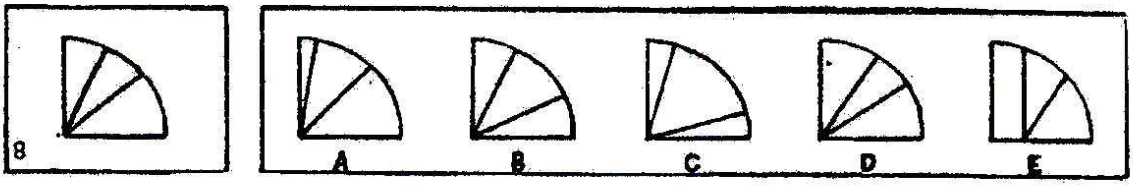


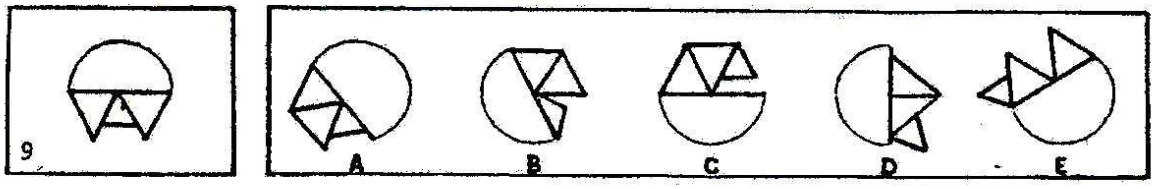



5
A
B
C
D
E


6
A
B
C
D
E


7
A
B
C
D
E


8
A
B
C
D
E

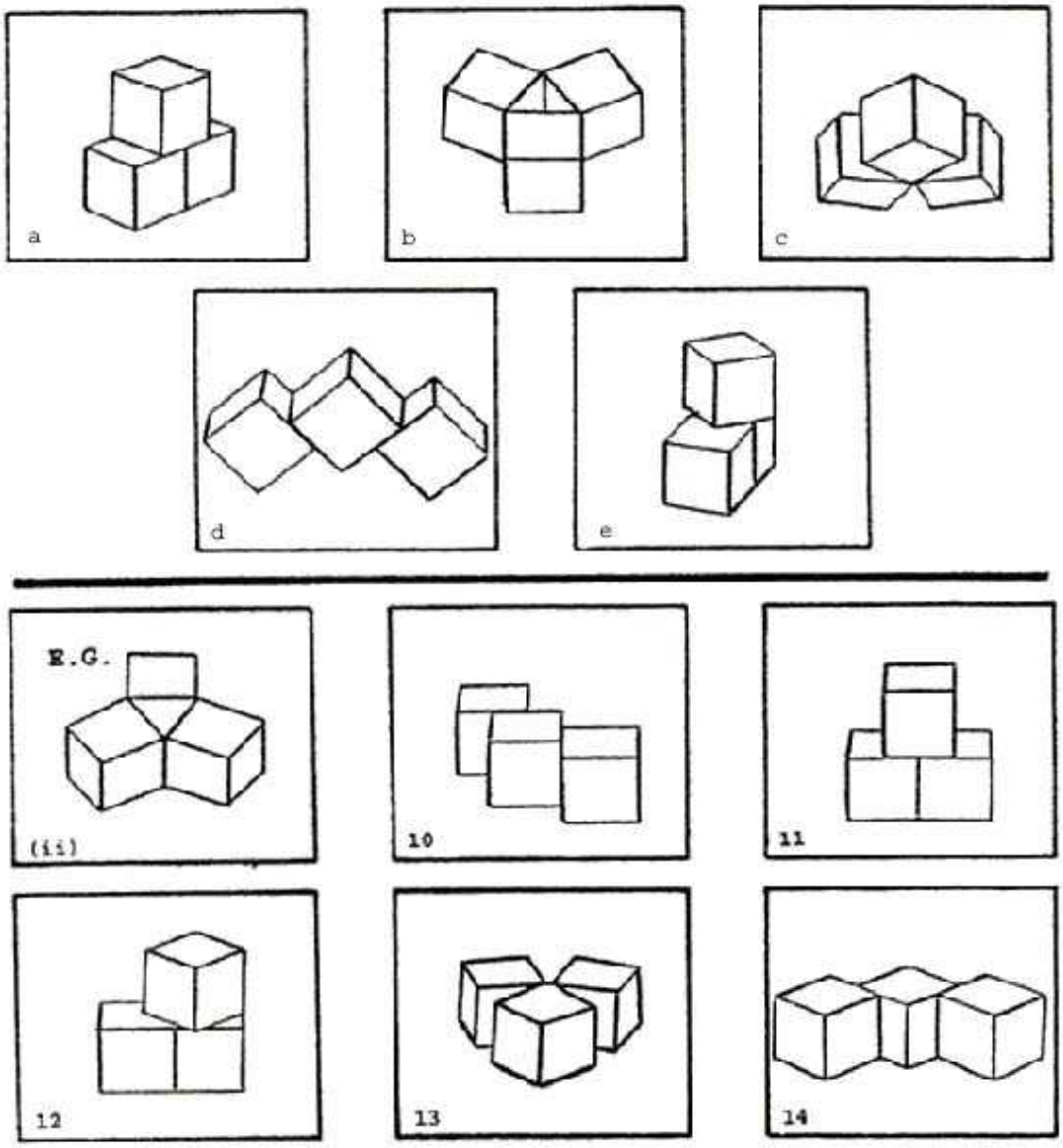

9
A
B
C
D
E

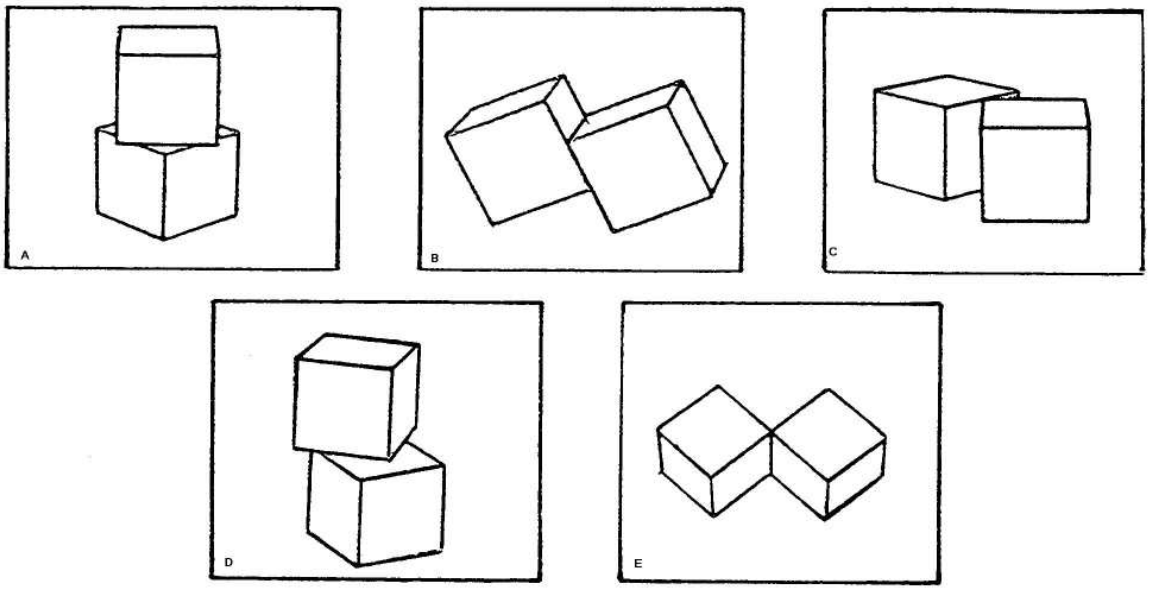
PART 3

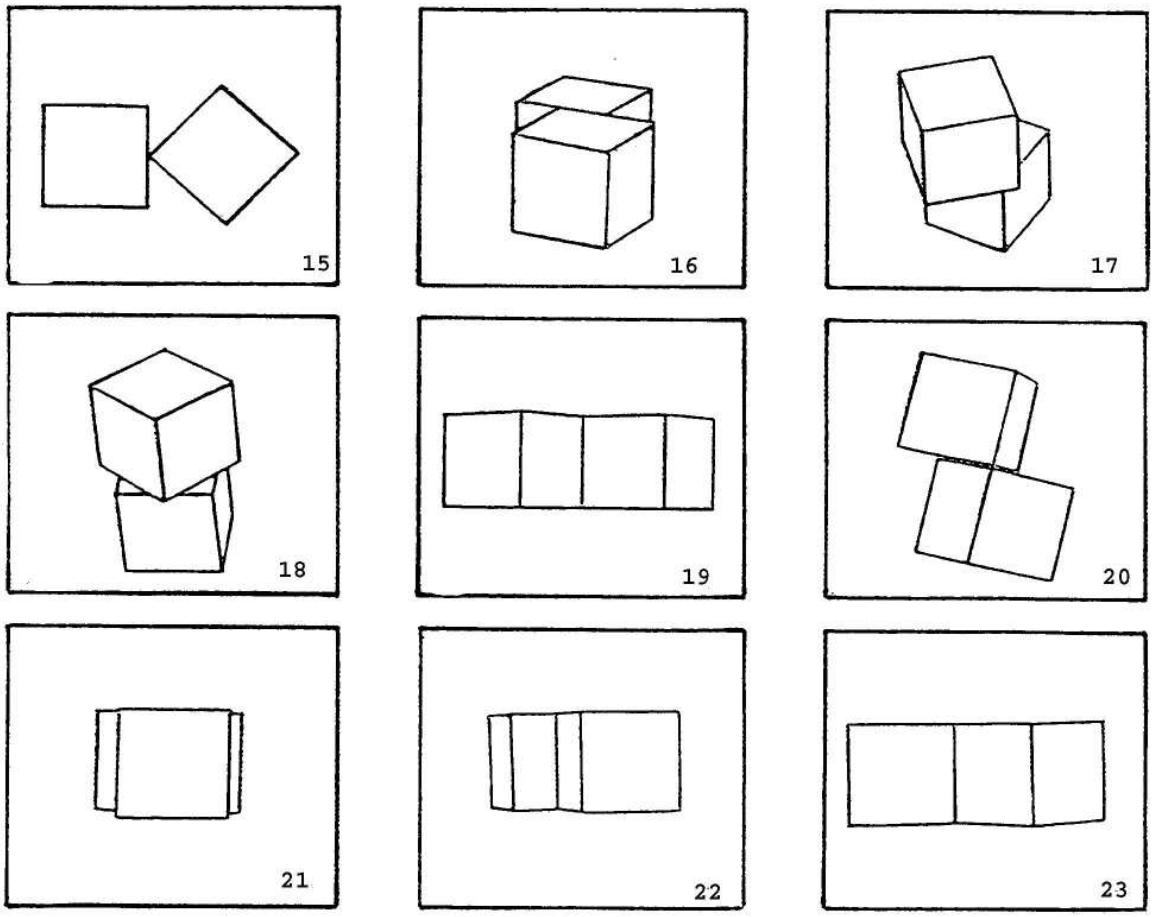
Each page of the test is divided into two by a heavy black line. Above the line there are five different sets of blocks, lettered A,B,C,D and E. Below the line are different sets of blocks, but viewed from other angles. The drawings below the line are the test questions. Study each question carefully and decide which one of the five drawings above the line, is a drawing of the same set of blocks. There is only one correct answer for each question.

Question (ii) below is an example. B is a drawing of the same set of blocks but viewed from another angle. Therefore, cross out letter B on the answer sheet next to number (ii).

Answer from question no. 10 to no. 23



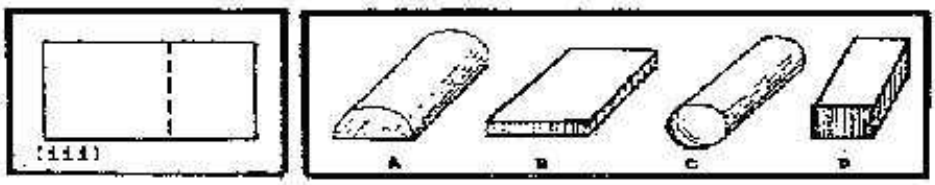

A
B
C
D
E


15
16
17
18
19
20
21
22
23

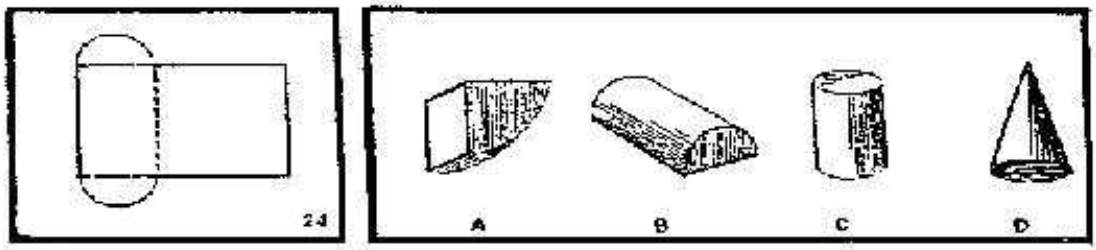
PART 4

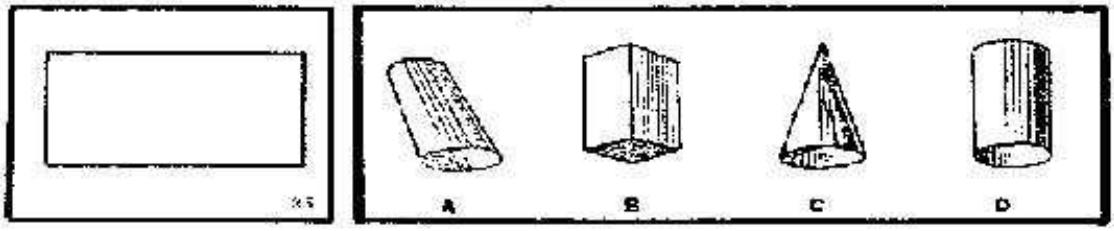
These are exercises in finding objects made from pieces of metal or cardboard. In the example below, on the left is a drawing which represents a flat piece of metal. The dotted lines indicate where the metal is to be bent. On the right are drawings of four objects. In each exercise, only one object can be made by bending the metal piece. Therefore, in the example (iii) cross out A on the answer sheet next to number (iii).

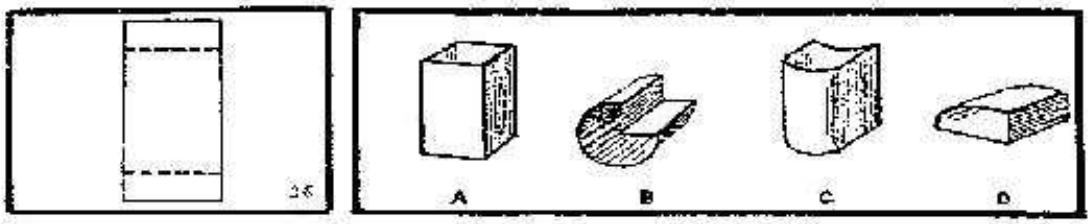
For example (iii)

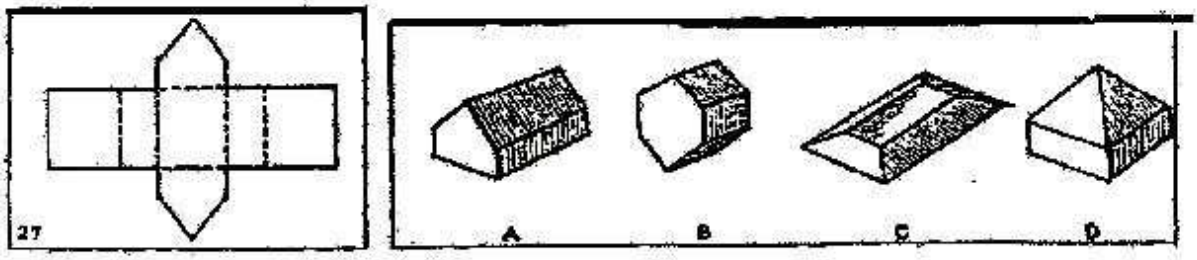


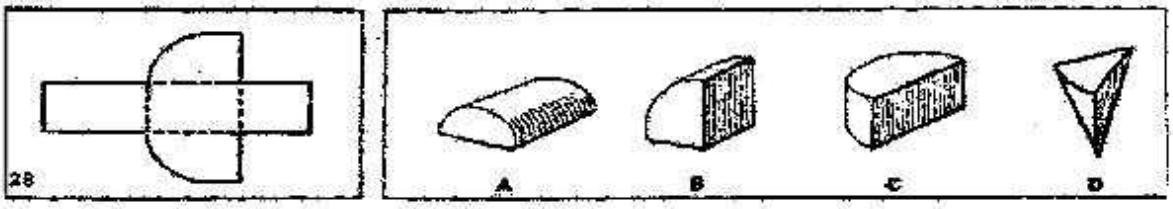
Do the following:

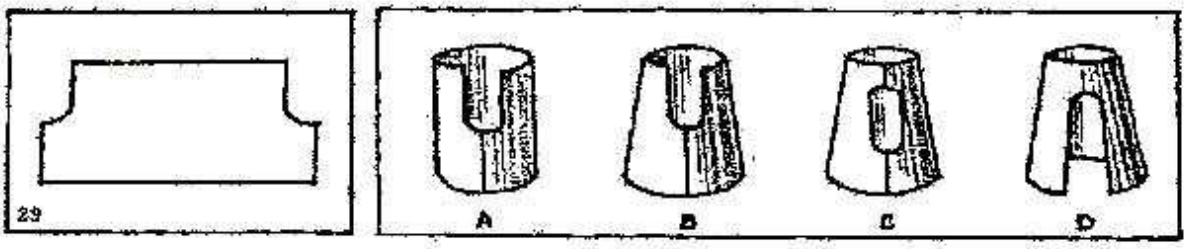


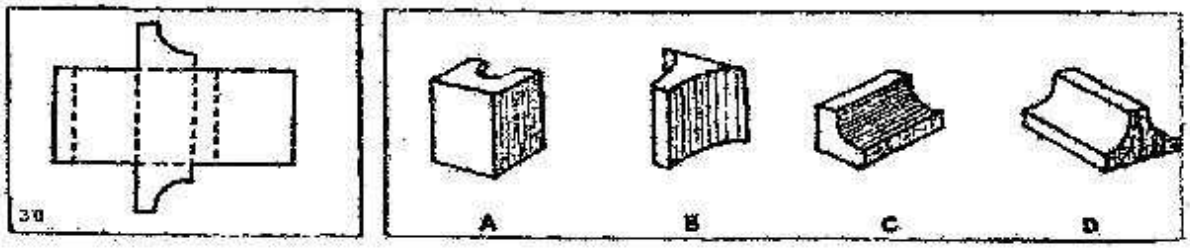





27
A
B
C
D


28
A
B
C
D


29
A
B
C
D


30
A
B
C
D

Part 5

This test has been carefully designed to measure your ability to think and reason.

READ THESE INSTRUCTIONS FIRST
A. INSTRUCTIONS

1. **Answer all questions.** If you do not know the answer - guess. Do not leave any questions unanswered.
2. If a question seems to have more than one answer or no correct answer at all, pick what you consider to be the best of the choices given. These questions are purposely designed to test your ability to think and reason.
3. Always indicate the correct answer.

B. SAMPLE QUESTIONS

Carefully study the following sample questions before beginning the test.

I. In some questions you will be asked to make a comparison.
Example: Which one of the five makes the best comparison?
Boat is to water as airplane is to:
(a) SUN (b) GROUND (c) WATER (d) SKY (e) TREE

The answer is sky. A boat travels through water. This can be compared to an airplane which travels through the sky.

II. In some questions, you will be given a group of five things. Four of them will have something in common; they will be similar in some way. You will be asked to choose the one which is not similar to the other four.
Example: Which one of the five is least like the other four?
(a) DOG (b) CAR (c) CAT (d) BIRD (e) FISH

The answer is car. The others are all living animals. A car is not alive.

III. There will also be some problems which you will be asked to solve. These will not require any difficult math. Instead, they will be testing how logical you are - that is, how well do you think.

QUESTIONS

31. Which one of the five is least like the other four?
(a) BEAR (b) SNAKE (c) COW (d) DOG (e) TIGER

32. If you rearrange the letters "BARBIT", you would have the name of a:
(a) OCEAN (b) COUNTRY (c) PROVINCE (d) CITY (e) ANIMAL

33. Which one of the five is least like the other four?
(a) POTATO (b) WHEAT (c) APPLE (d) CARROT (e) BEAN

34. Salim, twelve years old, is three times as old as his brother. How old will Salim be when he is twice as old as his brother?
(a) 15 (b) 16 (c) 18 (d) 20 (e) 21

35. Which one of the five makes the best comparison?
Brother is to sister as niece is to:
(a) MOTHER (b) DAUGHTER (c) AUNT (d) UNCLE (e) NEPHEW

36. Which one of the five makes the best comparison?
Milk is to glass as letter is to:
(a) STAMP (b) PEN (c) ENVELOPE (d) BOOK (e) MAIL

37. Which one of the five choices makes the best comparison?
LIVE is to EVIL as 5232 is to:
(a) 2523 (b) 3252 (c) 2325 (d) 3225 (e) 5223

38. "If some Smaugs are Thors and some Thors are Thrains, then some Smaugs are definitely Thrains."
This statement is: (a) TRUE (b) FALSE (c) NEITHER

39. Which one of the five makes the best comparison?
Tree is to ground as chimney is to:
(a) SMOKE (b) BRICK (c) SKY (d) GARAGE (e) HOUSE

40. If you rearrange the letters "MANGERY", you would have the name of a:
(a) OCEAN (b) COUNTRY (c) PROVINCE (d) CITY (e) ANIMAL

41. Which one of the five is least like the other four?
(a) TOUCH (b) TASTE (c) HEAR (d) SMILE (e) SEE

42. Sipho is taller than Peter, and Bill is shorter than Sipho.
Which of the following statements would be most accurate?
(a) Bill is taller than Peter.
(b) Bill is shorter than Peter.
(c) Bill is as tall as Peter.
(d) It is impossible to tell whether Bill or Peter is taller.

43. Which one the five is least like the other four?
(a) STOCKING (b) DRESS (c) SHOE (d) WALLET (e) HAT

44. Which one of the five makes the best comparison?
CAACCAC is to 3113313 as CACAACAC is to:
(a) 13133131 (b) 13133313 (c) 31311131 (d) 31311313 (e) 31313113

45. If you rearrange the letters "RAPIS", you would have the name of a:
(a) OCEAN (b) COUNTRY (c) PROVINCE (d) CITY (e) ANIMAL

46. "If some Bifurs are Bofurs and all Gloins are Bofurs, then some Bifurs are definitely Gloins."
This statement is: (a) TRUE (b) FALSE (c) NEITHER

47. Which one of the five makes the best comparison? Water is to ice as milk is to:
(a) HONEY (b) CHEESE (c) CEREAL (d) COFFEE (e) COOKIE

48. The price of an article was cut 20% for a sale. By what percent must the item be increased to again sell the article at the original price?
(a) 15% (b) 20% (c) 25% (d) 30% (e) 40%

49. Which one of the five is least like the other four?
(a) BOTTLE (b) CUP (c) TUB (d) FUNNEL (e) BOWL

50. Musa had a number of cookies. After eating one, she gave half the remainder to her sister. After eating another cookie, she gave half of what was left to her brother. Musa now had only five cookies left. How many cookies did she start with?
(a) 11 (b) 22 (c) 23 (d) 45 (e) 46

51. Which one of the five is least like the other four?
(a) COPPER (b) IRON (c) BRASS (d) TIN (e) LEAD

52. Which one of the five makes the best comparison?
Belt is to buckle as shoe is to:
(a) SOCK (b) TOE (c) FOOT (d) LACE (e) SOLE

53. "If all Wargs are Twerps and no Twerps are Gollums, then no Gollums are definitely Wargs."
This statement is: (a) TRUE (b) FALSE (c) NEITHER

54. Which one of the five makes the best comparison?
Finger is to hand as leaf is to:
(a) TREE (b) BRANCH (c) BLOSSOM (d) TWIG (e) BARK

55. "John's mother sent him to the store to get 9 large cans of peaches. John could only carry 2 cans at a time. How many trips to the store did John have to make?
(a) 4 (b) 4½ (c) 5 (d) ½ (e) 6

56. Zola was both 13th highest and 13th lowest in a spelling contest.
    How many people were in the contest?
    (a) 13 (b) 25 (c) 26 (d) 27 (e) 28

57. Which one of the five is least like the other four?
    (a) HAM (b) LIVER (c) SALMON (d) PORK (e) BEEF

58. "If all Fleeps are Sloops and all Sloops are Loopies, then all Fleeps are definitely Loopies."
    This statement is: (a) TRUE (b) FALSE (c) NEITHER

59. Which one of the five is least like the other four?
    (a) CM (b) KILOMETRE (c) ACRE (d) METRE (e) MILLIMETRE

60. Sipho received R0.41 change from a purchase in the supermarket.
    If he received six coins, three of the coins had to be:
    (a) CENTS (b) FIVE CENTS (c) TEN-CENTS (d) TWENTY CENTS (e) FIFTY CENTS

PART 6

Structure

This section is designed to measure your ability to recognize language that is appropriate for standard written English.

Directions: Questions 1-4 are incomplete sentences. Beneath each sentence you will see four words or phrases, marked A, B, C, and D. Choose the **one** word or phrase that best completes the sentence.

Look at the following examples:

Example I

Sample Answer

Geysers have often been compared to volcanoes _____ they both emit hot liquids from below the Earth's surface.

A. due to
B. because
C. in spite of
D. regardless of

The sentence should read, "Geysers have often been compared to volcanoes because they both emit hot liquids from below the Earth's surface." Therefore, you should choose answer B.

Example II

Sample Answer

During the early period of ocean navigation, _____ any need for sophisticated instruments and techniques.

A. so that hardly
B. where there hardly was
C. hardly was
D. there was hardly

The sentence should read, "During the early period of ocean navigation, there was hardly any need for sophisticated instruments and techniques." Therefore, you should choose answer D.

QUESTIONS

61. Refrigerating meats _____ the spread of bacteria.
    A. retards
    B. retarding
    C. to retard
    D. is retarded

62. Throughout the animal kingdom, _____ bigger than the elephant.
    A. whale is only the
    B. only the whale is
    C. is the whale only
    D. only whale is the

63. The fact _____ money orders can usually be easily cashed has made them a popular form of payment.
    A. of
    B. that
    C. is that
    D. which is

64. The constitution of South Africa gives parliament _____ to pass laws.
    A. the power
    B. has the power
    C. the power is
    D. of the power

PART 7

Written Expression

This section is designed to measure your ability to recognize language that is appropriate for standard written English.

Directions: In questions 5-10, each sentence has four underlined words or phrases. The four underlined parts of the sentence are marked A, B, C, and D. Identify the **one** underlined word or phrase that must be changed in order for the sentence to be correct.

Look at the following examples:

Example I **Sample Answer**

Guppies are sometimes call (A) rainbow fish (B) because (C) of the males' bright (D) colors.

The sentence should read, "Guppies are sometimes called rainbow fish because of the males' bright colours." Therefore, you should choose answer A.

Example II **Sample Answer**

Serving (A) several term (B) in Congress, Shirley Chisholm became an important (C) United States politician. (D)

The sentence should read, "Serving several terms in Congress, Shirley Chisholm became an important United States politician." Therefore, you should choose answer B.

QUESTIONS

65. Electrical (A) disturbances on Earth are frequently (B) caused with (C) storms on the surface (D) of the sun.
66. Dr. Dart, a teacher in South Africa, identification (A) the Taung Skull as hominid and believed (B) it represented (A) the "missing link" between (B) apes and humans.
67. A deficient (A) of folic acid is rarely found (B) in humans because (C) the vitamin is contained in (D) a wide variety of foods.
68. The gopher digs (A) with the strong claws of its (B) two front foot (C) and with its overhanging (D) front teeth.
69. The cosmonaut (A) and the world's second space tourist (B), Mark Shuttleworth, displayed (C) excitement about them (D) plans for genetic experiments in space.
70. As (A) two nuclei move closer together, their mutual (B) electrostatic potential energy becomes (C) more large (D) and more positive.

PART 8

Reading Comprehension

This section is designed to measure your ability to read and understand short passages similar in topic and style to those found in tertiary institutions.

Directions: In this section you will read a passage which is followed by a number of questions about it. You are to choose the **one** best answer, A, B, C, or D, to each question.

Answer all questions about the information in a passage on the basis of what is **stated** or **implied** in that passage.

SAMPLE PASSAGE AND QUESTIONS

The railroad was not the first institution to impose regularity on society, or to draw attention to the importance of precise timekeeping. For as long as
Line merchants have set out their wares at daybreak and
(5) communal festivities have been celebrated, people have been in rough agreement with their neighbours as to the time of day. The value of this tradition is today more apparent than ever. Were it not for public acceptance of a single yardstick of time, social life would be unbearably
(10) chaotic: the massive daily transfers of goods, services, and information would proceed in fits and starts; the very fabric of modern society would begin to unravel.

Example I

Sample Answer

Ⓐ Ⓑ ● Ⓓ

What is the main idea of the passage?

A. In modern society we must make more time for our neighbours.
B. The traditions of society are timeless.
C. An accepted way of measuring time is essential for the smooth functioning of society.
D. D. Society judges people by the times at which they conduct certain activities.

The main idea of the passage is that societies need to agree about how time is measured in order to function smoothly. Therefore, you should choose answer C.

Example II

Sample Answer

Ⓐ Ⓑ Ⓒ ●

In line 7, the phrase "this tradition" refers to

A. the practice of starting the business day at dawn
B. friendly relations between neighbours

C. the railroad's reliance on time schedules
D. people's agreement on the measurement of time

The phrase "this tradition" refers to the preceding clause, "people have been in rough agreement with their neighbours as to the time of day." Therefore, you should choose answer D.

READ PASSAGE

Two young men, John and Charles, were on their way back to their home village of Bahati, 18 kilometres outside of Nakuru, Kenya. They began talking about all the problems they had encountered in Nairobi since their arrival six months before. Like so many Kenyan youth from the rural areas they had left their village after finishing Form Four and tried to find jobs in Nairobi. John got a job washing dishes in a small restaurant. Charles was a good handy man and got occasional work as a day labourer in an outdoor garage. It was not much but it was a start.

John and Charles joined a group of young men connected to one of the main opposition parties called "Movement for a New Kenya." Their charismatic leader regularly spoke out against the bribery and corruption in the government. They often participated in protest rallies. The political rallies were exciting and the youth volunteered a lot of their free time. Several times violence took place after the political rallies. The two young men enjoyed the ferment of the big city, but they didn't have enough money to go to nightspots and bars regularly.

Then everything started to go wrong. One day there was a big riot in downtown Nairobi and three people were killed. The "movement's" leader was arrested and put in detention. The government declared him an "Enemy of the State." The two young men were dejected. Their hopes for a "New Kenya" were dashed.

To make matters worse, John's picture appeared in the coverage of the riot in one of the daily newspapers. When his boss heard about it, John was immediately fired. (6)Then their small flat was broken into and they lost most of their belongings. After Charles had malaria three times, the garage did not want him back. John and Charles started bumming around.

When their money finally ran out they decided to return to their village. Near Naivaisha the bus had a flat tyre and everyone had to get out. While waiting by the road John and Charles struck up a conversation with one man. They explained how they put their hopes in one of the main opposition parties but now their leader was in detention. The "movement" was in disarray. The stranger said that he was a lawyer and asked them some challenging questions about their commitment to bringing about social change in Kenya. The lawyer said that he wasn't taken in by some of the fast-talking politicians and their many promises. But he was committed to work for change from the grassroots up and to be a "voice of the voiceless."

The lawyer mentioned several important African stories and novels that contain a lot of wisdom for today's world. He gave the example of sharing a meal together. He said fast food restaurants in Nairobi destroyed the value of eating together in a relaxed family-style way and explained how a meal is perhaps the most basic and ancient symbol of friendship, love and unity. The stranger used the African proverb *"relationship is in the eating together"* to explain how a pleasant meal can build community and trust. He talked about the human and spiritual values in sharing together. John and Charles followed his words very intently. Then they shared their own views. But when they got to Nakuru with a quick wave the man was out the door and gone. The two youths sat amazed. Now he was gone.

QUESTIONS

71. The passage primarily discusses
    a) bus trip
    b) Kenyan politics
    c) lawyer
    d) riots
72. The word "they" in line 2 refers to
    a) bus driver and the flat tyre
    b) trip
    c) John and Charles
    d) Meals
73. The word "charismatic" in line 11 is closest in meaning to
    a) insensitive
    b) evil
    c) uninteresting
    d) appealing
74. According to the passage the two young men enjoyed
    a) buzz of the city
    b) money
    c) their government
    d) girls
75. The phrase "bumming around" in line 29 is closest in meaning to
    a) running from one place to another
    b) sitting down and doing nothing
    c) singing riot songs
    d) sharing foot
76. The author mentions all of the following as important to change in society EXCEPT
    a) change taking place from grassroots level upward
    b) fast talking politicians
    c) representing the "voices of the voiceless"
    d) community sharing
77. John and Charles joined the
    a) church groups
    b) ruling party
    c) rioting groups of villages
    d) one of the opposition parties
78. Which of the following best describes the political change led by the ordinary people
    a) commitment to work for change from grassroots up.
    b) sharing a meal together
    c) "relationship is in the eating together"
    d) reading several books which contain wisdom and value for human life.
79. The phrase" was out the door" is closest in meaning to
    a) leaving
    b) kicking out the door
    c) opening the door very widely
    d) standing outside the door.
80. Where in the passage is it illustrated that the bus had problems
    a) line 18
    b) line 25
    c) line 31
    d) line 49

End

Thank you very much for your participation in this exercise

ANNEX 2

Questionnaire developed to identify specific misconceptions held by students regarding photosynthesis and respiration

Questionnaire on photosynthesis and respiration

This questionnaire forms part of my PhD project. Its purpose is to assess students' knowledge about photosynthesis and respiration in order to identify common misconceptions. The information will be used to develop more effective teaching in this area.

The questionnaire contains 13 questions about photosynthesis and respiration in plants. Each question has three parts. The first part is a standard multiple-choice question on a particular concept of photosynthesis. Please mark the option that you feel answers the question most fully.

The second part asks you why you chose the answer you did this is also multiple choice. Again, please mark the reason that most fully explains your answer. If you feel that none of the options provide a satisfactory answer, space is provided for you? Write your reason. The last part asks you how confident you feel about your answer, either not at all confident, somewhat confident, confident, or very confident. The appropriate choice should be marked

Thank you for your assistance.

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Question 1

Plants produce "food" (chemical compounds which can be broken down to meet the energy requirements of the plant) through which process?

a) Absorption of minerals through the roots
b) Photosynthesis
c) Transpiration
d) Respiration

The reason for my answer is that:

a) Transpiration is the process whereby water and nutrients are transported to all parts of the plant.
b) Minerals in the soil are directly metabolised by the plant for energy.
c) Respiration is the production of glucose and other sugars which are used as a source of energy for the plant.
d) light energy is trapped by chlorophyll molecules and used to convert CO_2 and water to glucose and other simple sugars, which are used as a source of energy for the plant.
e) _____

How confident are you of your answer'?

a) not at all
b) somewhat
c) confident
d) very confident

Question 2

Photosynthesis and respiration are

a) the same process
b) opposite processes
c) complementary processes

The reason for my answer is that:

a) Both processes use light energy and release O_2
b) Both processes use light energy and release CO_2

c) Photosynthesis is a constructive process that may lead to an increase in mass of the plant, whereas respiration is a destructive process that may lead to a decrease in mass of the plant.

d) the products of photosynthesis are used as reactants in respiration (i.e. the simple sugars produced by photosynthesis are broken down through respiration to release energy for the plant.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 3

What gas is given out in largest amounts by green plants in the presence of sunlight?

a) CO_2

b) O_2

The reason for my answer is that

a) This gas is given off in the presence of light because green plants respire only during the day.

b) Green plants only photosynthesize and do not respire in the presence of light energy,

c) There is more of this gas produced by the plant during photosynthesis than is needed by the plant for respiration and other processes, so the excess gas is given off.

d) This gas is a by-product given off by green plants as they photosynthesize.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 4

Which gas is taken in by green plants in the largest quantities in the presence of light energy?

a) C O_2

b) O_2

The reason for my answer is that

a) This gas is used in respiration which takes place only in the presence of light energy

b) This gas is used in photosynthesis which takes place only in the presence of light Energy.

c) This gas is used in photosynthesis, which takes place continuously

d) This gas is used in respiration, which takes place continuously.

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 5

Which gas is taken in by green plants in large amounts when there is no light present?

a) C O_2

b) O_2

The reason for my answer is that

a) This gas is used in photosynthesis, which takes place only in the dark

b) This gas is used in photosynthesis, which takes place continuously

c) This gas is used in respiration, which takes place continuously

d) This gas is used in respiration, which takes place only in the dark.

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 6

Which gas is given off in large amounts when there is no light energy at all?

a) CO_2

b) O_2

The reason for my answer is that:

a) Green plants stop photosynthesizing when there is no light energy, but they continue to respire, and therefore they give off this gas.

b) This gas is given off by the green plant during photosynthesis, which takes place when there is no light energy.

c) Because plants respire only when there is no light energy, they give off this gas.

d) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 7

The light phase of photosynthesis takes place

a) only in the presence of light

b) only in the dark

c) continuously

The reason for my answer is that:

a) the light phase involves electron transport, which only takes place when sunlight excites chlorophyll molecules, causing them to give up electrons.

b) the light phase involves the uptake of CO_2, which takes place only in the light.

c) the light phase involves the uptake of CO_2, which takes place only in the dark.

d) the light phase involves the uptake of CO_2, which takes place continuously.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) confident

Question 8

The dark phase of photosynthesis takes place

a) only at night (in the dark)

b) only in the day (in the presence of light energy) c) during the day and night (continuously)

The reason for my answer is that:

a) the dark phase involves the excitation of chlorophyll molecules by light, leading to electron transport,

b) the dark phase involves the uptake and reduction of CO_2, which takes place only in the presence of light.

c) the dark phase involves the uptake and reduction of CO_2, which takes place only in the absence of light.

d) the dark phase involves the uptake and reduction of CO_2, which does not necessarily require light, and so takes place continuously

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 9

The light phase of photosynthesis

a) is the opposite of the dark phase.

b) uses products of the dark phase for reactants in the light phase.

c) is complementary to the dark phase, and the products of the light phase act as reactants in the dark phase.

The reason for my answer is that:

a) The light phase products are NADPH and A TP, which are used in the dark phase to combine CO_2 and ribulose bisphosphate to produce glucose.
b) Products of the dark phase are NADPH and A TP, which are used in electron transport during the light phase.
c) The light phase produces NADPH and A TP for electron transport in the dark phase.
d) The light phase occurs only in the light and produces A TP, while the dark phase occurs only at night and produces NADPH.
e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 10

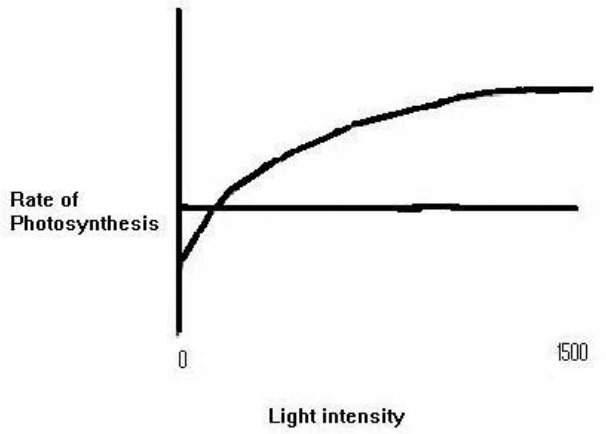

Figure 1: The rate of photosynthesis in relation to light intensity

Figure 1 shows the rate of photosynthesis measured at different light intensities.

Point I on the graph is the

a) light compensation point
b) point at which light saturation has occurred

The reason for my answer is:

a) At this point, increased light leads to an increase in photosynthesis.

b) At this point, an increase in light intensity yields no further increase in photosynthesis.

c) At this point, the rate of photosynthesis equals the rate of respiration.

d) At this point, the rate of respiration is greater than the rate of photosynthesis.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 11

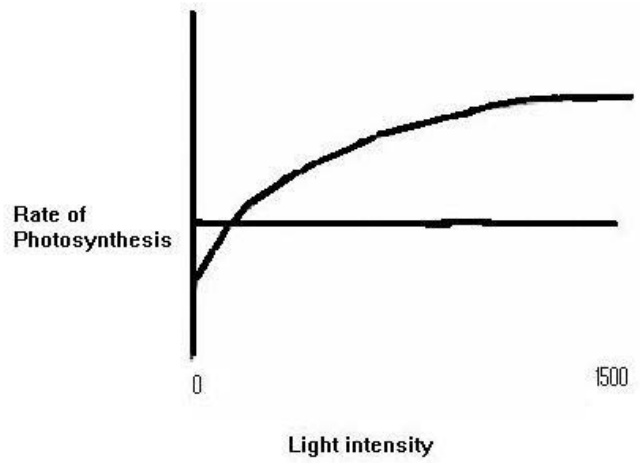

Figure 2. The rate of photosynthesis in relation to light intensity

Figure 2 shows the rate of photosynthesis measured at different light intensities. At point I

a) photosynthesis has ceased

b) the rate of photosynthesis increases as light intensity increases.

c) the rate of photosynthesis stays the same even though light intensity increases.

The reason for my answer is that:

a) At this point, light has become the limiting factor

b) At this point, some other factor has become the limiting factor.

c) At this point, there is too much light and the plant is no longer photosynthesizing.

d) At this point, respiration is greater than photosynthesis.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 12

Which of the following equations best represents the overall process of photosynthesis?

a) Glucose + oxygen $\xrightarrow[\text{light energy}]{\text{chlorophyll}}$ CO_2 + water

b) CO_2 + water $\xrightarrow[\text{light energy}]{\text{chlorophyll}}$ Glucose + oxygen

c) CO_2 + water + energy > Glucose + oxygen

The reason for my answer is that:

a) The green pigment, chlorophyll, combines with the CO_2 in the presence of light energy and produces glucose and water.

b) The energy from sunlight is used by plants containing chlorophyll to combine CO_2 and water to form glucose and oxygen.

c) Glucose and oxygen is combined in the presence of chlorophyll and light energy to Form CO_2 and water.

d) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 13

Which of the following equations best represents the process of respiration in plants?

a) Glucose + oxygen > energy + CO_2+ water

b) CO_2+ water > energy + glucose + water

c) CO_2+ water —(light energy, chlorophyll)→ > oxygen + glucose

d) Glucose + oxygen > CO_2 + water

The reason for my answer is that

a) During respiration, green plants take in CO_2 and water in the presence of light energy to form glucose.

b) CO_2 and water are used by the green plant to produce energy during which time Glucose and oxygen waste are produced

c) During respiration green plants take in oxygen and give off CO_2 and water.

d) During respiration, green plants derive energy from glucose, using oxygen, and releasing CO_2 and water in the process.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

ANNEX 3

Questionnaire developed to identify specific misconceptions held by students regarding photosynthesis and respiration

Questionnaire on photosynthesis and respiration

This questionnaire forms part of my PhD project. Its purpose is to assess students' knowledge about photosynthesis and respiration in order to identify common misconceptions. The information will be used to develop more effective teaching in this area.

The questionnaire contains 8 questions about photosynthesis and respiration in plants. Each question has three parts. The first part is a standard multiple-choice question on a particular concept of photosynthesis. Please mark the option that you feel answers the question most fully.

The second part asks you why you chose the answer you did this is also multiple choice. Again, please mark the reason that most fully explains your answer. If you feel that none of the options provide a satisfactory answer, space is provided for you? Write your reason. The last part asks you how confident you feel about your answer, either not at all confident, somewhat confident, confident, or very confident. The appropriate choice should be marked.

Thank you for your assistance.

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Question 1

What gas is given out in largest amounts by green plants in the presence of sunlight?

a) CO2
b) O2

The reason for my answer is that:

a) This gas is given off in the presence of light because green plants respire only during the day.
b) Green plants only photosynthesize and do not respire in the presence of light energy.
c) There is more of this gas produced by the plant during photosynthesis than is needed by the plant for respiration and other processes, so the excess gas is given off.
d) This gas is a by-product given off by green plants as they photosynthesize.
e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 2

Which gas is taken in by green plants in the largest quantities in the presence of light energy?

a) CO_2
b) O_2

The reason for my answer is that:

a) This gas is used in respiration which takes place only in the presence of light energy
b) This gas is used in photosynthesis which takes place only in the presence of light Energy.
c) This gas is used in photosynthesis, which takes place continuously
d) This gas is used in respiration, which takes place continuously.
e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 3

Which gas is taken in by green plants in large amounts when there is no light present?

a) CO_2
b) O_2

The reason for my answer is that:

a) This gas is used in photosynthesis, which takes place only in the dark
b) This gas is used in photosynthesis, which takes place continuously
c) This gas is used in respiration, which takes place continuously
d) This gas is used in respiration, which takes place only in the dark.
e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 4

What gas is given off in large amounts when there is no light energy at all?

a) CO_2
b) O_2

The reason for my answer is that

a) Green plants stop photosynthesizing when there is no light energy, but they continue to respire, and therefore they give off this gas.

b) This gas is given off by the green plant during photosynthesis, which takes place

c) When there is no light energy.

d) Because plants respire only when there is no light energy, they give off this gas.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 5

The light phase of photosynthesis takes place

a) only in the presence of light

b) only in the dark

c) continuously

<u>The reason for my answer is that:</u>

a) The light phase involves electron transport, which only takes place when sunlight excites chlorophyll molecules, causing them to give up electrons.

b) The light phase involves the uptake of CO_2, which takes place only in the light.

c) The light phase involves the uptake of CO_2, which takes place only in the dark.

d) The light phase involves the uptake of CO_2, which takes place continuously.

e) _____

How confident are you of your answer?

a) not at all

b) somewhat

c) confident

d) very confident

Question 6

The dark phase of photosynthesis takes place

a) only at night (in the dark)
b) only in the day (in the presence of light energy)
c) during the day and night (continuously)

The reason for my answer is that:

a) The dark phase involves the excitation of chlorophyll molecules by light, leading to, electron transport.

b) The dark phase involves the uptake and reduction of CO_2, which takes place only in the presence of light.

c) The dark phase involves the uptake and reduction of CO_2, which takes place only in the absence of light.

d) The dark phase involves the uptake and reduction of CO_2, which does not necessarily require light, and so takes place continuously.

e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 7

The light phase of photosynthesis

a) is the opposite of the dark phase.
b) uses products of the dark phase for reactants in the light phase.
c) is complementary to the dark phase, and the products of the light phase act as reactants in the dark phase.

The reason for my answer is that:

a) The light phase products are NADPH and A TP, which are used in the dark phase to combine CO_2 and ribulose bisphosphate to produce glucose.

b) Products of the dark phase are NADPH and A TP, which are used in electron transport during the light phase.

c) The light phase produces NADPH and A TP for electron transport in the dark phase.

d) The light phase occurs only in the light and produces A TP , while the dark phase occurs only at night and produces NADPH.

e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

Question 8

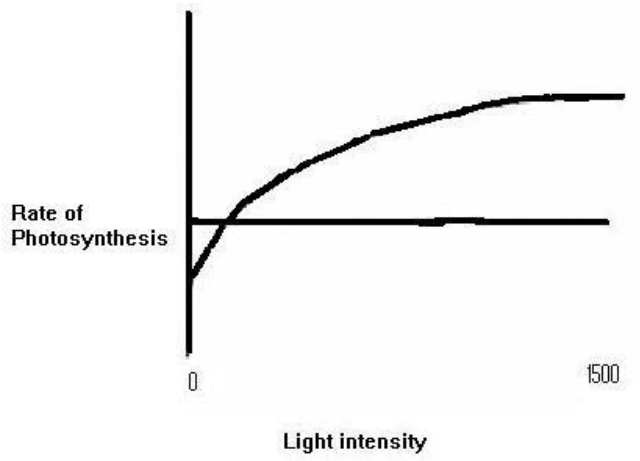

Figure 1. The rate of photosynthesis in relation to light intensity

Figure 1 shows the rate of photosynthesis measured at different light intensities. Point I on the graph is the:

a) light compensation point
b) point at which light saturation has occurred

The reason for my answer is that:

a) At this point, increased light leads to an increase in photosynthesis.
b) At this point, an increase in light intensity yields no further increase in photosynthesis.
c) At this point, the rate of photosynthesis equals the rate of respiration.
d) At this point, the rate of respiration is greater than the rate of photosynthesis.
e) _____

How confident are you of your answer?

a) not at all
b) somewhat
c) confident
d) very confident

ANNEX 4

Focus Group Questions

1. Do you like playing games?
2. What kind of games do you like to play?
3. Why do you think some people prefer to use computers for learning?
4. Why did you want to participate in the *yKhozi*?
5. Was playing the game easy?
6. Why yes/no?
7. How interesting were the topics covered by the game (Cancer, HIV/AID, TB)??
8. Do you think talking to your group members helps you in understand the topics covered by the game better?
9. Do you think that games, such as *yKhozi*, can be used as an alternative way of teaching, instead of using teachers?
10. Why?
11. Do you think girls are more interested in using computers than the boys?
12. Why do you think girls are interested in this game?
13. Why do you think that some people prefer playing games for learning?
14. Do you think playing *yKhozi* in groups could help improve the way learners think?
15. How if yes?
16. Do you think playing the game in groups helped you to understand the topics better?
17. Do you think that your visual skills can be improved by playing *yKhozi*?
18. Why do you think some boys are not interested in the game?