

**Evaluation of ArcView-GIS as a Learning Tool at the
University of KwaZulu-Natal**

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Declaration

I Nhlanganiso Biyela hereby declare that, this dissertation for the Masters of Digital Media Degree submitted by me at the ITed, University of KWAZULU-NATAL has not previously been submitted for a degree or diploma at this or any University, and that it is my work. All reference materials contained herein have been duly acknowledged.

Date 26/04/2006

Signed:



Nhlanganiso Biyela

Dedication

- To God for giving me wisdom, courage and endurance in all my academic endeavours
- To the most precious and wonderful memory of my late mother, Miss Rebecca Thembi Biyela, who passed away at the dawn of the finalisation of this work. Thank you for believing in me and listening to my every dream. Without your never-ending love, interest, guidance, motivation and support I would not have come this far. May your memories live on.

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Abstract

The objective of the research project is to investigate the use of ArcView-GIS (a Geographical Information Systems software package) to promote cognitive development at the University of KwaZulu-Natal. To understand the impact of ArcView-GIS as a learning tool will require an understanding of how it is used, what learning goals are held by educators and students and the type of assessments used to evaluate student achievement. It is argued that the use of GIS software promotes development of a wide range of skills. A research instrument to measure skills related to visualization, language, mathematics and logics was used to evaluate learners from a number of different groups which included science undergraduates, humanities undergraduates and GIS students (2 groups: one group took the test after the completion and the other group prior to the GIS course). In addition GIS experts and students evaluated the user interface of ArcView-GIS. Results show that those learners exposed to GIS performed better in all the skills evaluated than any of the other groups. Also, experts and GIS students found the software interface satisfactory. The findings suggest that ArcView-GIS can support higher-order thinking by engaging students in authentic, complex tasks within an appropriate learning context.

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CHAPTER 1 – INTRODUCTION

1.1 Introduction

This chapter provides an introduction to and outline of the rest of the dissertation. The purpose of this dissertation is to investigate whether ArcView-GIS (a Geographical Information Systems software package) promotes cognitive development in students studying a GIS course at the University of KwaZulu-Natal. Some of the features of ArcView-GIS that might promote the learning of GIS will be discussed and will then be evaluated. Tests, as well as interviews, are used to determine whether ArcView-GIS promotes cognitive development. In particular this investigation examines the knowledge, skills and attitudes of the participants before and after the use of ArcView-GIS.

1.2 Background of study

As mentioned above, this dissertation investigates whether ArcView-GIS promotes cognitive development in students studying a GIS course at the University of KwaZulu-Natal.

ArcView-GIS is a desktop Geographic Information System (GIS) from the Environmental Systems Research Institute (ESRI). A GIS is a database that links information to location, allowing the user to visualize, explore, query and analyze geographic data spatially (ESRI homepage 2004).

ArcView-GIS works with views, tables, charts, layouts, and scripts stored in one file called a *project*. A project file stores information about the contents and status of each project component, including storage locations of the data sets used in the project. The actual data are not stored in the project file. Hence, if any data set is updated, the updates are also reflected in the ArcView-GIS project. However, this also means that data sets cannot be moved to another location without updating the project file. A view is an interactive map that enables display, exploration, queries and analysis of geographic data. Tables and charts work in a fairly similar manner as a simple spreadsheet in the sense that

the tables include data records with several columns, and that charts can be created from the values in data columns. The strength of the ArcView-GIS tables and charts is the connection to the geographic data in the view. A layout is the framework for preparing graphical output, such as maps, charts, and table records, for hardcopy printing or to be saved on files for import into word processors or publishing applications. A script is the component of an ArcView-GIS project that contains AVENUE code. AVENUE is an object-oriented programming language, from which ArcView-GIS is developed (ESRI homepage 2004).

The project files also include information on the display status, screen location, size etc. of the various component windows. The ArcView-GIS user's interface also includes menu, button and tool bars at the top of the ArcView-GIS window. These vary for each ArcView-GIS component, and the menu, button and tool bars shown in the ArcView-GIS window are always the ones for the active window. The ArcView-GIS window also includes a status bar at the bottom of the window. The ArcView-GIS interface is stored in the file 'default.apr' in the 'etc' sub-directory below the ArcView-GIS installation folder (ESRI homepage 2004).

1.3 Statement of the problem

This dissertation uses tests, questionnaires, observations, as well as interviews to determine whether ArcView-GIS promotes cognitive development, with the view of giving recommendations to improve the situation and environment.

1.4 Major research questions

- Does ArcView-GIS provide a user-friendly interface for learners to engage with GIS knowledge?
- Does ArcView-GIS meet its aim in terms of its functions?
- Did students change in terms of knowledge, skills and attitudes after finishing the GIS course?

1.5 Major research questions

Chapter 1 briefly introduces the research questions and includes a description of ArcView-GIS. The next chapter discusses the need for skills in the South Africa market, investigates cognitive development, human-computer interaction (HCI) theories, relationship of technology with cognitive development, theories, and also gives a general review of literature of ArcView-GIS. Chapter 3 presents the research methodology from the view point of the eclectic mixed-methods pragmatic paradigm. Chapter 4 presents the analysis of the data collected using the mix methodological approach. This dissertation closes with a conclusion in Chapter 5 along with suggestions for improvement and presents the limitations in the study.

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

This chapter deals with theories of cognitive development and human-computer interaction (HCI) that form the cornerstone of this research on the evaluation of ArcView-GIS by users (experts and students). It also looks at the debates and arguments that have taken place about the software that support cognitive development and constructivist learning principles.

The first part of the chapter will briefly discuss the need for skills in South Africa, and then discuss some of the theories of cognitive development and HCI theory. This chapter will also discuss the relationship of technology with cognitive development theories, argue if ArcView-GIS is appropriate for learning GIS and discuss user interfaces and usability issues related to the software. The discussion of user interface and usability issues will help in the evaluation of the effectiveness of the software, as it will help to determine whether there is any change in knowledge, skills and attitudes in students.

2.2 Skills in South Africa

In South Africa today there is a great need for the development of a skilled and technically sophisticated work force. As South Africa's rating on the world competitiveness scale drops i.e. there are less skilled people in South Africa compared to many other countries, so this need becomes greater and more vital. In this study, South Africa was reported to be right at the bottom of a list of 41 countries in terms of the number of skilled people per country (*Sunday Times*, November 24, 1996.).

Knowledge of GIS is one such technical kind of knowledge that is required in South Africa as is evidenced by the many weekly job advertisements in the National Sunday Times newspaper. GIS can provide many fundamental thinking skills which underpin scientific and technical thought. One of the guiding principles of the new education curriculum in South Africa, which was introduced in 1998, is to develop such scientific

skills (Further Education and Training Act, 1998). Thus there is a need more than ever before to educate effectively in computer software such as ArcView-GIS.

Graduates also need to be technically literate, and to have well-developed critical thinking and problem-solving skills. The new Education Department curriculum emphasises these skills over the old-style curriculum's emphasis on memorisation of content (Further Education and Training Act, 1998). It is claimed that ArcView-GIS might provide skills to individuals to make better decisions about Geography related developments (Goodchild, 2000). In this study ArcView-GIS will be evaluated in order to know whether it does indeed promote spatial and visual perception skills related to cognition.

2.3 Theoretical framework

2.3.1 Cognitive Development

The study of cognition can be subdivided into problem solving and reasoning (Dix, 1998). In discussing cognitive development, two main theories will be discussed that branch from constructivism. Constructivism is a theory of pedagogy that is based on the emphasis of learners who will create and develop ideas from their constructed knowledge (Piaget, 1970). The two strands of constructivism discussed here are cognitive constructivism of Jean Piaget and social constructivism of Lev Vygotsky.

In Piaget's cognitive development theory there is a belief that humans cannot be spoon-fed information to learn from but instead knowledge construction depends on: what is already known, previous experience, organization of these experiences beliefs that the individual uses to interpret the reality of objects and events encountered, and also be able to create mental models (schemas which the individual uses to represent the world and designate action). This adaptation is driven by a biological drive to obtain balance between schemas and the environment (Piaget, 1970). Piaget (1970) hypothesizes that humans have schemas that they use to adapt to the environment, those schemas are quickly replaced with constructed schemas (Piaget, 1970). Piaget (1970) described two cognitive processes that are essential to the individual to progress from stage to stage,

namely assimilation and accommodation. The overall focus of cognitive development is intelligence (Piaget, 1970). Schemata are intellectual structures. Assimilation involves the interpretation of events in terms of existing cognitive structures, whereas accommodation refers to changing the cognitive structures to make sense of the environment and equilibration is a balance between assimilation and accommodation to form new internal mental structures which learners would use to further evaluate the external world in the future development.

Suchmann (1962) agrees with Piaget's concepts of constructivist learning, active participation, and the concepts of disequilibrium, believed that learners are internally motivated to learn. Anything that is puzzling or unknown is bound to place the mind in a state of disequilibrium, thus causing the learner to seek new knowledge so that the mind can be in the state of equilibrium again.

Vygotsky (1971) believes that cognitive development takes place through social and collaborative activity that cannot be taught. Bruner (1971) supported Vygotsky, in that cognitive development depends on social interaction. Bruner (1966) argues that instruction should aid humans in their thinking and humans can perform a task when given instructions and assistance i.e. cognitive development can take place if individuals are scaffold. For Vygotsky (1971), "scaffolding" is the process of providing a learner with a good deal of support during the time they are learning something. This support is reduced as the learner becomes able to deal with the task independently, resulting in their taking on increasing responsibility for their own learning.

Bruner (1977) argues that learners should be encouraged to discover things for themselves. This author stressed the importance of learning, how to learn which the author understood as the ability to transfer the knowledge or skills from one situation to another. "Learning should not only take us somewhere, it should allow us later to go further more easily" (Bruner, 1977). Bruner (1983) further explains that the act of learning involves three processes: acquisition of information, transformation adjusting the

knowledge to particular tasks and evaluation by checking whether the adjustment of knowledge is appropriate for the task.

If opportunities to learn new things are presented to learners, they will learn and develop. According to Donaldson (1978) young learners should be given opportunities to learn based on their inborn curiosity. Donaldson (1978) uses the term ‘imaginative embedding’ to characterise the process in which the learners fit the problem or task in a real world context and she believes that this process is an important part of making sense of logical problems.

Feuerstein (1980) believed that cognitive structures may be modified to develop their full potential (structural cognitive modifiability). Cognitive modifiability (Feuerstein, 1980) refers to structural changes, or the changes of the state of the organism, brought about by a deliberate program of intervention that will facilitate the generation of continuous growth by rendering the organism receptive and sensitive to internal and external sources of stimulation. Donaldson (1978) also discussed researches which prove that children do better on cognitive tasks if these tasks appear in a context that makes human sense to the child. She particularly emphasises the ability of a child to place a task in a socially meaningful context.

Feuerstein (1980) proposes the concept of “mediators”. Mediation is characterised by certain features. It is related to empowering the learner to acquire knowledge, skills or strategies, to become more autonomous and to develop as independent thinkers. Feuerstein (1980) describes mediation as the way in which stimuli emitted by the environment are transformed by a mediating agent, usually a parent, sibling or other caregiver. Feuerstein (1980) agrees with other constructivism theorists that the learner is an active participant in constructing knowledge. Feuerstein (1980) argues that mediation shapes students the way they perceive the environment.

Vygotsky and Piaget have a critical difference in their views of cognitive development. Vygotsky's main and basic criticism of Piaget is that thinking develops from the social level to the individual, while it is opposite for Piaget.

The main difference between Piaget and Vygotsky lies in the ability to learn, to construct and there are inborn familiarities. Piaget sees the individual as the source of learning and that children learn by continuous interaction and experience with their environment, the egocentric speech is valuable for logical thinking but it can also obscure the meaning. Instead Vygotsky emphasises that one cannot learn without the verbal interaction and activity with others.

It has been shown that learning is more effective when it is activity-based rather than passively received (Brown, 1989). The active "constructing" or "doing" of tasks leads to discovery. The concept of discovery learning is not new. Discovery learning can be described as experimentation with some extrinsic intervention -- clues, coaching, a framework to help learners get to a reasonable conclusion. It has appeared many times in educational philosophy. Dewey (1938) stated that "there is an intimate and necessary relation between the processes of actual experience and education". It is also supported by learning theorists/psychologists such as Piaget, Bruner, and Papert, "In so far as possible, a method of instruction should have the objective of leading the child to discover for himself" (Dewey 1938).

Bruner (1961) believes that discovery learning assists learners to take responsibility for their own learning, emphasizes exploring, experimenting, doing research, asking questions, and helps students remember important facts.

Cognitive development has been labeled cognitive theory because cognitive development is facilitated by activities or situations that engage learners and require adaptation (Bruner, 1999). Much has been researched and written by many eminent leaders in the field of cognition. For example the phenomenon of human learning has been studied for centuries and it is generally agreed that two main streams exist in learning research,

namely learning as behaviour and learning as cognition. Both schools of thought are relevant and should be viewed on a continuum, where, in any given learning environment, the appropriate strategy is chosen depending on the expected learning outcome (Tapscott, 1998).

Tapscott (1998) explains how students construct knowledge from information presented. A student works on the processes by selecting relevant information, organizing links which are made between the selected pieces of information and integrating links between the new information and prior knowledge to evaluate the information. Once this process has been completed, one can say that knowledge has been created and learning has taken place.

In order to create knowledge, students need to do something with the information. They need to interact with the information. On interacting with information, they may notice a lack of knowledge and that will force them to search for more information to do away with deficiency. Tapscott (1998) added that information is something which affects and transforms the recipient's state of knowledge when perceived.

Human Computer Interaction (HCI) is another concept which contributes to cognitive development. "HCI is the parts of a computer system (hardware and software) that the user can see, feel and hear and can use to control the computer" (Preece, 1994). It allows the exchange of information between the user and the computer.

2.3.2 Human Computer Interaction (HCI)

Cognitive and social constructivism theories have contributed immensely to the understanding of cognitive development. Human Computer Interaction (HCI) is another concept which contributes to cognitive development because HCI incorporates metaphors which are used to allow the user to be better able to predict the outcomes of new interactions (Murrell, 2001). "Metaphor also allows the designers to work with a model which will guide the development in a consistency of interactions and representations" (Murrell, 2001).

According to Preece (1994), the empirical study of HCI is rooted in experimental cognitive psychology. Cognitive psychology is the study of how people think and learn. The goal of cognitive psychology is to understand the psychological processes involved in the acquisition and use of knowledge by people. This includes domains such as perception, attention, memory, learning, thinking, and the importance of social and environmental influences on those domains. The importance of this definition is that it stresses the need for scientific analysis and includes processes. HCI and cognitive psychology are related in the sense that information about human characteristics is needed to guide design towards features that are compatible with memory capabilities, the nature of human learning of facts and skills, the methods of cognitive psychology can be used to evaluate designs and the user interface features (Preece, 1994).

HCI is concerned with studying and improving the many factors that influence the effectiveness and efficiency of computer use. It combines techniques from psychology, computer science, and ergonomics (Preece, 1994).

The purpose of the study of HCI is to enhance the quality of the interaction between human and machine and to systematically apply knowledge about human purposes, capabilities, and limitations, and machine capabilities and limitations, so as to extend our reach, so as to enable us to do things we could not do before (Preece, 1994).

HCI makes the computer technology more usable to people and requires an understanding of four things: (a) the computer technology, (b) the people who interact with it, (c) what is meant by 'more usable,' (d) and the work that people are trying to perform by using the technology (Dix 1998). The aim of HCI is also to provide a safe, comfortable, and satisfying experience for the user (Preece, 1994).

HCI has shaped modern computing in the sense that computer interfaces contain elements such as the mouse, windows, icons and various graphical user interfaces. HCI is the

study, planning, and design of how people and computers work together so that a person's needs are satisfied in the most effective way.

The *user interface* is the part of a computer and its software that people can see, hear, touch, talk to, or otherwise understand or direct. The user interface has essentially two components: input and output. *Input* is how a person communicates their needs or desires to the computer. *Output* is how the computer conveys the results of its computations and requirements to the user (Galitz, 2002). According to Preece (1994) for the computer to be usable it must comprise the extent, to which it can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use, where:

- ◊ **Effectiveness** measures the accuracy and completeness with which users achieve specified goals;
- ◊ **Efficiency** measures the resources expended in relation to the accuracy and completeness with which users achieve goals;
- ◊ **Satisfaction** measures the freedom from discomfort, and positive attitudes towards the use of the software (Preece, 1994).

In order for a computer or software to be effective, “its user interface must not throw a panel full of buttons, labels, and scrollbars onto the screen. Instead, it must look right and it must act right” (Preece, 1994).

Through interaction with the user interface, users construct their own mental models of the system, how it is organized, and how it behaves. If all goes well in the human computer interface design, the user interface and the models on which it is organized will seem familiar and understandable to the user because they have been presented clearly and simply through the user interface and because, ultimately, they are based upon how the users work and understand their own work (Preece, 1994).

The software should be usable, without help or instruction, by a user who has knowledge and experience in the application domain but no prior experience with the system, meaning that the software must support the user without having to read manuals. The

software should not interfere with or impede efficient use by a skilled user, who has substantial experience with the software, but support the expert user's needs and as well support the beginner (Preece, 1994).

The software should facilitate and support continuous advancement in knowledge, skills and accommodate progressive change in usage as the user gains experience with the system (Preece, 1994). This means that some connection is needed between the simpler and the more advanced facilities, which the details of the user interface, should actively aid the user in understanding and using additional features and acquiring new skills. Instead of leaving users on their own to cope with advanced but arbitrary features that are difficult to learn, good software helps users to become power users for example, by furnishing shortcuts that are naturally related to the longer means preferred by beginners. The software should support the real work that users are trying to accomplish by making it easier, simpler, faster, or more fun or by making new things possible. The software should go beyond supporting established ways of working; it must open new possibilities (Constantine and Lockwood, 1999).

Software should be suited to the real conditions and actual environment of the operational context within which it will be deployed and used. Software should be easy to learn how to use, and, once learned, remembering how to use it should be easy as well. In fact there must be relationship between technology and cognitive development theories. The software must be designed to support the cognitive development (Constantine and Lockwood, 1999). Perhaps the area of development most researched in relation to computer use has been that of cognitive development. The question that has been raised, "how are these technologies affecting learner's minds?" Are they being used as tools to enhance and hasten cognitive development, or are they detracting from and inhibiting intellectual growth in some way? The answers, at best, have been very mixed.

Cognitive development theories have been used to explain the relationship between learner's computer use and development, for example, the theory of constructivist purported by Piaget (1970).

2.3.3 Relationship of Technology with Cognitive Development Theories

Constructivism concerns the process of how students create meaning and knowledge in the world as well as the results of the constructive process. How students construct knowledge depends upon what they already know, their previous experiences, how they have organized those experiences into knowledge structures such as schema and mental models, and the beliefs they use to interpret the objects and events they encounter in the world. Cognitive tools help learners organize, restructure, and represent what they know. Constructivists seek to create learning environments wherein learners use cognitive tools to help themselves construct their own knowledge representations.

Cognitive constructivist theory inspired scholars like Papert and Bruner. Papert's work in the area of educational technology resulted in creation of LOGO. Papert (1993) constructed the LOGO project to assist cognitive development in learners. He used the theoretical ideas of Piaget (1970) as a basis for the design of software which facilitated the process of cognitive development. Papert (1993) developed a number of powerful ideas e.g. turtle graphics, for the design of computer based learning environments. The ideas were embodied in the design of the language LOGO and the learning interactions it was used to support. Papert (1993) introduced LOGO to assist learner's cognitive development. The best known feature of LOGO is Turtle Graphics. The turtle is a small floor robot which responds to commands written in LOGO. Alternatively, and more abstractly, the turtle may be represented by the cursor on the computer screen. A program is a set of instructions the learner gives to the turtle to do a task, such as draw a rectangle or a triangle. In a subsequent program the learner may combine these procedures to create more complex shapes, such as the drawing of a house (Boyle 1997).

Papert (1993) was particularly concerned with introducing children to mathematics. Many mathematical concepts seem too difficult for learners to grasp. The turtle graphics was a transitional object which allows the learners to make sense of tasks in terms of everyday familiar experience, but supports them in moving into the world of the abstract. Within LOGO mistakes are treated not as errors but as opportunities to learn. Making

errors a productive part of the learning process is another important theme of cognitive development (Boyle 1997).

According to Fowler (2001) students possess different kinds of minds and therefore learn, remember, perform, and understand in different ways. Gardner (1991) argues that we are all able to know the world through language, logical-mathematical analysis, spatial representation, musical thinking, the use of the body to solve problems or to make things, an understanding of other individuals, and an understanding of ourselves. Where individuals differ is in the strength of these intelligences - the so-called profile of intelligences -and in the ways in which such intelligences are invoked and combined to carry out different tasks, solve diverse problems, and progress in various domains (Gardner, 1991).

Cognitive and behaviourist theories provide the explanatory structure within which to understand cognitive development. Cognitive learning is demonstrated by knowledge recall and intellectual skills: comprehending information, organizing ideas, analyzing and synthesizing data, applying knowledge, choosing among alternatives in problem-solving and evaluating ideas or actions. Piaget (1971) explained that learning deals with our mental processes such as thinking, learning, remembering, and feeling. The focuses are on how people perceive, process, store and retrieve information. The behaviorists focus on what can be observed and reject the notion of scientifically measuring what goes on inside a subject's brain; cognitive theorists are most interested in the mental processes and feel that these processes can be studied empirically. While these processes cannot be seen, their effects can be observed and measured. Both the work of Piaget and Vygotsky provide a framework for intervention (Riddle & Dabbagh 1999).

Behaviourists represent one of the key principles of positivism: that knowledge of the world can only change from observation of objective facts and phenomena. Cognitivists argue that a person's response to stimuli is individual and depends on their cognitive state and the mental processes occurring (Dalgarno, 1996). The acknowledgement of a reciprocal relationship between learning and memory 'what we learn' is affected by its meaningfulness. The meaningfulness is determined by what is remembered and that

memory is affected by what we learn (Winn and Snyder, 1996) and between knowledge and environment has led to a philosophical shift within educational psychology, from objectivism to constructivism.

The students need to search for meaning and understanding from the information they interact with in order to cognitively develop instead of memorising facts for tests or examinations. They need to learn when, where and why to use information received as well as how to recognise meaningful patterns in the information in order to cognitively develop in the subject matter (Tapscott, 1998).

The students need to apply some form of cognitive strategy in order to solve given problems. If applied successfully, the cognitive strategy should lead to mastery of the subject matter. Students need to think about and discuss their own approach to learning, and be willing to explore alternatives. For learners to be able expand their cognitive development they need to become autonomous and they need to think about learning itself. A common misconception is that a person becomes autonomous on becoming an adult. This is rarely the case, as discussed by Steyn (1998). The student needs to be convinced that they need to become an independent lifelong learner (Tapscott, 1998).

Visualisation is a process for putting (complex) images into minds e.g. the shape of a mountain, images of street maps, memory of street names, verbal directions. According to Rieber (1995) visualisation is a key cognitive strategy which plays an important role in discovery and problem solving e.g. the information acquired through visualisation can be used to make simple route-finding decisions. In that case people learn about space and the objects and routes within space. Visualisation, therefore, has tremendous value in GIS because of spatial data which is always manipulated by the GIS people. Also, many of the problems presented in GIS require the manipulation of objects, or elements. Leutner (1993) argues that manipulation of objects stimulates learning and training. Through a process of visualization, a GIS can be used to produce images not just maps, but drawings, animations, and other cartographic products. These images allow researchers to

view their subjects in ways that they never could before. The images often are helpful in conveying the technical concepts of a GIS to nonscientists.

Information is cognitively processed in an electronic information environment. In problem solving, studies indicate that while working in a technology enriched learning environment, evaluation of information measured against Bloom's Cognitive Taxonomy was found to be significantly higher, analysis and synthesis of information were found to be generally higher. Creativity by learners exploring the unknown, taking individual initiative to find solutions, was also exhibited (Bloom, 1956). Bloom's taxonomy of cognitive objectives, originated by Benjamin Bloom and collaborators in the 1950's, describes several categories of cognitive learning. Three "domains" of educational activities were identified. Psychomotor Domain Taxonomy which is characterized by progressive levels of behaviors from observation to mastery of a physical skills. Cognitive Domain involves knowledge and the development of intellectual attitudes and skills. Affective Domain Taxonomy: lists levels of commitment (indicating affect) from lowest to highest

Eventually, Bloom and co-workers established a hierarchy of educational objectives, which is generally referred to as Bloom's Taxonomy, and which attempts to divide cognitive objectives into subdivisions ranging from the simplest behaviour to the most complex.

The focus of this research is on the assumption that ArcView-GIS helps student to develop cognitively in GIS. The theoretical framework which informs a developmental approach to the evaluation of how ArcView-GIS helps students to develop in GIS is derived from a synthesis of work of Tapscott (1998) where the author explains the influences of computers on students. Cognitive learning is concerned with human information processing, integration of new with prior knowledge, meta cognition, internal schemata, retention and transfer of learning, and the use of cognitive strategies. According to Tapscott, (1998) (see Table 1) computers can facilitate the process of learning by

- Supplementing limited working memory by making large amounts of information immediately available for the learners use,
- Making relevant, previously learned information available simultaneously with the acquisition of new information,
- Enabling learners to quickly retrieve previously learned information that is needed to help them in learning specific new information, and
- Prompting the learner to structure, integrate, and inter, and interconnect new ideas with previous ones.

The influence of computers on students are summarised in Table 1. The psychomotor, cognitive and affective perspectives used in Table 1 to examine the influences were selected by Tapscott (1998).

Table 1. Influences of computers on students (from Tapscott, 1998).

Psychomotor influences e.g. the physical skills	<ul style="list-style-type: none">• Using computers students became active, they participate, inquire, argue, critique, ridicule, seek and inform.• They want to be users, not just viewers or listeners.
Cognitive influences : understandings, awareness, insights	Using computers learners have to: <ul style="list-style-type: none">• develop critical skills to judge if the information has any value;• develop critical skills as they do tasks in groups, e.g. students can learn to leadership skills, lesson to each other.• develop evaluation skills to see if the information is fact or fiction;• develop investigative skills to find the required information• develop presenting skills;• question the implicit values contained in the information, as there is so much information.
Affective influences: attitudes, appreciations, relationships	<ul style="list-style-type: none">• Young people hungry for expression, discovery and their own self development. They control the software, creating their own environment, developing their own feeling of autonomy and sense of values.

As a result of the *psychomotor influences*, the consequence for information processing in an educational environment is that the learner needs to be active and can not be expected to passively absorb information.

As a result of the *cognitive influences*, the consequences for information processing in an educational environment are as follows: (1) The content matter must be of a high quality, i.e. learning materials must be linguistically and factually of a high standard; (2) Learners need content matter to evaluate and criticise, i.e. a single source of information is not stimulating enough; and (3) Learners must have the opportunity to find their own information.

As a result of the *affective influences*, the consequences for information processing in an educational environment are as follows: (1) Information presented in such an environment must be as stimulating as that found on the internet; (2) Learners need to control the creation of their own information; and (3) Learners need autonomy in finding and evaluating their own information.

Cognitive tools activate complex cognitive learning strategies and critical thinking. These tools not only extend the mind, they have the potential to reorganize mental functioning (Pea, 1985). When using cognitive tools, learners engage in knowledge construction rather than knowledge reproduction. Cognitive tools are also intended to be used by students to represent knowledge and solve problems while pursuing investigations that are relevant to their own lives. Cognitive tools empower learners to design their own representations of knowledge rather than absorbing knowledge representations preconceived by others.

Technology is defined as "any object or process of human origin that can be used to convey media" Reeves (1998). According to Reeves (1998), learning "with" technology is referred to in terms such as cognitive tools. This author believes that technology can have positive effects on learning. Computer-based cognitive tools have been intentionally adapted or developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning. Computer software programs are examples of exceptionally powerful cognitive tools. Also referred to as cognitive technologies, technologies of the mind. Examples of cognitive tools include: databases, spreadsheets, the statistics tool SPSS and Microsoft Office (Reeves 1998).

Reeves (1998) outlined the foundations for using software as cognitive tools as follows:

- Cognitive tools will have their greatest effectiveness when they are applied within constructivist learning environments;
- Cognitive tools empower learners to design their own representations of knowledge rather than absorbing representations preconceived by others;
- Cognitive tools can be used to support the deep reflective thinking that is necessary for meaningful learning;
- Cognitive tools have two kinds of important cognitive effects, those which are *with* the technology in terms of intellectual partnerships and those that are *of* the technology in terms of the cognitive residue that remains after the tools are used;

- Cognitive tools enable mindful, challenging learning rather than the effortless learning promised but rarely realized by other instructional innovations;
- The source of the tasks or problems to which cognitive tools are applied should be learners, guided by teachers and other resources in the learning environment;
- Ideally, tasks or problems for the application of cognitive tools will be situated in realistic contexts with results that are personally meaningful for learners;
- Using multimedia construction programs as cognitive tools engages many skills in learners such as: project management skills, research skills, organization and representation skills, presentation skills, and reflection skills; and
- Research concerning the effectiveness of constructivist learning environments such as microworlds, classroom-based learning environments, and virtual, collaborative environments show positive results across a wide range of indicators.

According to Tapscott (1998) computers can facilitate the process of learning by:

- Supplementing limited working memory by making large amounts of information immediately available for the learners to use;
- Making relevant, previously learned information available simultaneously with the acquisition of new information;
- Enabling the learner to quickly retrieve previously learned information that is needed to help them in learning specific new information; and
- Prompting the learner to structure, integrate, and interconnect new ideas with previous ones.

2.4 ArcView-GIS literature

Many articles have been written about ArcView-GIS, but few explained how ArcView-GIS helps students to develop cognitively in a GIS. The articles have explained ArcView-GIS as a specialized tool to manipulate, retrieve, view, store and analyse spatial data. All features in a spatial database are comprised of geographic points, such as polygons, points and lines. These elements are linked to a table that uniquely identifies each feature and its location in a coordinate system. Data can be mapped and analyzed, and linked to

attribute data in one-to-one or many-to-one relationships. An ArcView-GIS combines layers of information about a place to give one a better understanding of that place. The layer chosen depends on the purpose of the map, such as analyzing environmental damage, or viewing similar crimes in a city to detect patterns. In a GIS, geographic data is described explicitly in terms of geographic coordinates, namely, latitude and longitude or grid coordinates, or implicitly in terms of a street address or postal code. A GIS translates implicit geographic data into an explicit map location. This process is called geocoding. A GIS system also has a database manager, usually a relational database management system (RDBMS) (ESRI, 2004).

ArcView-GIS introduces students to a new way of seeing, thinking, and interacting with the world around them. Using ArcView, students explore course content in a way that enhances logical, mathematical, linguistic, spatial, and interpersonal intelligences. Doing GIS projects is thought to improve critical thinking skills such as analyzing, synthesizing, and evaluating. For example students learn in no time to work with data geographically: seeing patterns they could not see before, revealing hidden trends and distributions, and gaining new insights. Working geographically enables you to understand relationships between the forces that drive your business so you will make better decisions and get the power you need to solve problems faster (Braus, 1998).

ArcView-GIS provides students with powerful learning tools that can be developed into marketable skills. According to Raymond (1994) graduates have found jobs because of their ArcView-GIS training which helped them develop skills. "ArcView-GIS enables students to take relatively simple classroom activities and extend them beyond the walls of University into the community" (Braus 1998).

According to Braus (1998) computers and maps have a natural appeal to students and the learning process is enriched when tasks or work of students can be used in "real life" applications e.g. students are given environmental impact assessment projects. ArcView-GIS can be used in a variety of creative ways in a learning environment, for example the students may be asked to generate traffic data and map out a group of possible freeway routes. Presenting results and ideas is easy with ArcView-GIS. Students can make

publication-quality maps and create interactive displays by linking charts, tables, drawings, photographs, and other files. Communicating geographically is a powerful way to inform .e.g. if people inform or locating a particular place for development, they use maps to describe the position.

ArcView-GIS draws from many different disciplines. It also integrates many technologies in one package, (e.g. spreadsheets and databases, but the main use is that the software has made it easier for students to draw maps.

There are also barriers to the use of ArcView-GIS. For ArcView-GIS to be used by more students, effective use of ArcView-GIS requires computer literacy. Students have to be fairly technologically oriented or have good support. Students must overcome issues ranging from discomfort with computer technology. The student must be trained to use computer technology (Braus, 1998).

According to Dawson (2004) computer skills come with regular use of the computer. The real skills of educational value, social and personal skills, must be developed during group interaction and the processing of information during authentic and challenging educational projects. By using ArcView-GIS students actually learn how to do statistical functions of selected database fields. In ArcView-GIS students are also exposed to statistical analysis tools concepts for example correlation, average, maximum, minimum and count. To learn more about statistical concepts a student can go to the help menu and search for statistical concepts. In that way ArcView-GIS does help students to develop the skill and knowledge in the field of statistics and students begins to understand the concepts and be able to use them correctly when performing statistics (Dawson, 2004).

Using ArcView-GIS is beneficial not only in developing computer literacy but also provides training in the process of research including gathering, preparing, storing, and analyzing data and presenting the results of analysis using a variety of methods. These are skills valuable in both academic and business settings. In addition to interacting with data in a new way, students learn teamwork because GIS projects typically require a high level of cooperation, because GIS uses data sets which require consultation between

different stakeholders. The importance of GIS to education is being recognized throughout the world (Braus, 1998).

Students develop their spatial knowledge when using ArcView-GIS. Understanding of relative locations of the students' residential country can be considered basic prerequisites that enable them to establish a framework in which further knowledge can be accumulated. Goodchild (1990) noted that only by mastering location and place could the student proceed to higher order geographical concept. Investigating learners' development of understanding of their country's geographical space is important for cartographers as this small-scale spatial information, which may be stored into the learners mind, comes mainly from maps. In the last decade there has been a renewed interest in learners' recall and understanding of the geographical units.

One of the most important functions of a spatial information system is that it enables the integration of databases from different sources and scales (Landis, 1993). The integration of information allows appropriate indicators to be developed (e.g. per capita funding for development).

According to Landis (1993), one of the most useful functions of spatial information or a GIS is the production of thematic maps. A thematic map is a map depicting selected kinds of information relating to one or more specific themes. Examples are soil type, land classification, population density and rainfall maps (Walker, 1993). Over the last year, South Africa has seen a marked increase in the use of mapped information in decision making. The overlaying of different layers of spatial information is another function that enables people to gain an understanding of the spatial relationship between features and enables information from one layer to be integrated with another. Overlay is a transparent sheet placed over artwork, in register with the work it covers; this is used to call out other color components of the work, instructions or corrections. A good example of this is the overlaying of census information with satellite imagery to show where areas of environmental degradation occur in relation to where populations with different socio-economic characteristics reside. Information from point locations (e.g. crime incidence,

schools, health facilities, development projects, social surveys, etc) can also be overlaid to get a better understanding of a particular area.

A GIS software use tools for the handling, collecting, managing, analysis and modeling of geographic data. A GIS strength lies in its ability to combine computer-assisted mapping with statistical analysis of spatial data to perform spatial modeling. A GIS can integrate a wide variety of disciplines including agriculture, computing, economics, and geography. It can assist in the analysis of many social and scientific problems on a global, national and local level. A GIS is used as the integration of spatial data acquired at different scales and times, and in different formats into a single database. It can be used for the enhancement of measurement, mapping, monitoring and modeling of spatial phenomena. Using a GIS improves our understanding of the world (ESRI homepage 2004).

A key concept for any GIS is to be able to ask 'what if?' type questions. This enables the decision-maker to derive a variety of solutions to different problems. The swift retrieval of data sets which shows the spatial relationships between features is also very significant and assists with the interpretation of the data. The ability to produce maps showing particular combinations of features is also a very valuable asset. Thus, the analysis capability, data management capability and the cartographic capability all help to enhance the ability to manipulate and use data more efficiently (ESRI homepage 2004).

A GIS helps develop students' critical thinking and problem solving skills so they will become more involved in their community and more responsible global citizens.

According to the World Health Organisation (1999) GIS "provide an excellent means of analysing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover in tabular format". The technology provides a mechanism to integrate different data sets, analyse their spatial and statistical components, and model possible scenarios, thereby supporting interdisciplinary research. Its use will encourage the ongoing collection and analysis of accurate spatial and statistical data for disease control and resource distribution. Its use requires appropriate

data, mechanisms for distribution, as well as expertise and technical support (Medical Research Centre, 2001).

According to Hazel Baker (1997) ArcView-GIS helps students to find employment for example GIS graduates are finding employment with ease, to the extent that most have jobs to go to as soon as they finish university. According to Hazel (1997) knowledge of a GIS is the technical knowledge that is needed by most companies.

ArcView-GIS may also help learners improve their reporting skills. ArcView-GIS may help by performing a number of valuable functions e.g. pre-processing/evaluating data, data displaying: display of spatial and editing of data and analysis of data: spatial and attribute query. They can also be used for producing multiple drafts of documents small data files, notices and research papers. The types of features are exploited include adding graphs, using comments and accessing external data. ArcView-GIS also helps students to analyze data by being reliable and accurate in numerical analysis. ArcView-GIS helps students to stay focused on their work by finding facts easily without leaving the work at hand, using the new research task pane. It brings electronic dictionaries, thesauruses, and online research sites into work to help students to find information and incorporate information into their work. Some functionality in the research task pane requires a connection to the Internet. ArcView-GIS also finds the help needed by a student from the 'getting started' and 'help' task panes. Students can also access ArcView-GIS Online assistance on the ArcView-GIS Online Web site. It provides help and assistance articles that are updated regularly from requests and issues of other users (ESRI homepage 2004). It is a tool that is structured in the way that may enhance the students mind and improve the knowledge of the GIS course material. ArcView-GIS promotes using systems customized to the students' prior knowledge and enhances student learning, ArcView-GIS is being designed with the philosophy and pedagogy reinforcing the inquiry-based approach to learning and it offers a collection of research-based inquiry technology, from probe, to Internet resources, all in an effort to support with the specific tools that researchers and students need. Also, it emphasizes hands-on problem solving.

Students have limitations to working memory because working memory can naturally handle less than seven ideas (larger numbers of ideas can be 'chunked' into less than seven larger pieces for thinking about in working memory) (Miller, 1956). ArcView-GIS can serve as an extender for working memory, holding larger numbers of ideas in an organized format for reflection and revision (Saloman, 1993). ArcView-GIS also presents coherent patterns in the form of a Graphic User Interface (GUI) that helps learners remember events, ideas and relations between observations and derived inferences. Also multiple forms of representation help provide multiple accesses to ideas. A GUI is the collection of controls that you use to interact with a project component. In ArcView-GIS each GUI is comprised of a menu bar, a button bar, a tool bar and a set of popup menus. A user can customize the default GUIs and create new GUIs. Each GUI is associated with a specific project component (ESRI homepage 2004).

ArcView-GIS gives students practice activities that are authentic to the GIS e.g. geographical search and spatial analysis; which makes it likely that students will be better able to perform in the GIS course. The authentic task would help learners in practical activities relevant within realistic scenarios. Cognitive learning theory indicates that the ways in which knowledge, skills, and attitudes are initially learned affect the degree to which these abilities can be used in other contexts. If knowledge, skills and attitudes are learned in a context of use, they will be used in similar contexts. Otherwise, it is left up to learners to generate connections between problems and solutions. Whenever transfer to real-world contexts is of primary concern, situating interactive learning in relevant contexts may be advantageous, although the research support for this is still weak (Reeves & Hedberg 2000). The students benefit from opportunities to use and apply their knowledge and skills in a variety of contexts. ArcView-GIS also supports students to develop evidence-based (case-based) reasoning to support or refute their scientific ideas. That support of ArcView-GIS gives students practice in deciding when it is appropriate to use particular knowledge and skills being acquired. Based upon Perkin's (1985) "knowledge as the design" pedagogy, learners undertake a task or solve a problem using software as a cognitive tool to support their problem-solving processes and ultimately to present their solutions to others. "Cognitive tools empower learners to design their own

representations of knowledge rather than absorbing knowledge representations preconceived by others” this is not a highly motivating process, but there is also good evidence that authorship result in ownership of the ideas in the representations (Reeves 1996).

According to Feuerstein (1979) Piaget’s theory of human cognition provides the explanatory structure within which to understand the different stages in the development of human cognition. Piaget outlined several principles for building cognitive structures. During all development stages, in relating the theory to ArcView-GIS, the students experience their environment using whatever mental maps they have constructed. If the experience is a repeated one, it fits easily or is assimilated into the student’s cognitive structure so that he or she maintains mental "equilibrium." If the experience is different or new, the student loses equilibrium, and alters their cognitive structure to accommodate the new conditions. This way, the student erects more and more adequate cognitive structures.

ArcView-GIS also helps students in analysing the data in the GIS course and gives the solutions to any given task for GIS course e.g. the location of the best route or the shortest point to a certain place. By this tool a student is developing in skill and knowledge because a tool is helping a student to solve that particular problem. Using ArcView-GIS in a structured setting is not beneficial only in developing computer literacy but also provides training in the process of research including gathering, preparing, storing, and analyzing data and presenting the results of analysis using a variety of methods. These are skills valuable in academic settings (Johnson, 2000).

It is argued that ArcView-GIS helps students to perform tasks that they are incapable of completing on their own. With this in mind, scaffolding where the software continually adjusts the level of its help in response to the student level of performance is an effective form of helping a student to develop cognitively. Scaffolding not only produces immediate results, but also instills the skills necessary for independent problem solving in

the future. Scaffolding means the provision of transitional support structures in learning (ESRI homepage 2004).

2.5 Conclusion

The chapter successfully dwelled on thoroughly giving an insight into the cognitive development, human computer interaction theories and relationship of technology with cognitive development theories ArcView-GIS literature. It was evident from the literature review that ArcView-GIS is thought to promotes cognitive development. Having discussed the ArcView-GIS, the next chapter will come with research methodology. The research methodology is going to test the above-mentioned literature.

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Introduction

Software systems such as ArcView-GIS are to guide developmental decisions. A system is successful if it assists in achieving the set goals. The outcome of evaluating software should be to provide a picture of how users can carry out the desired tasks, e.g. using statistical software to perform the statistics. The control that a software designer has is in the structuring of the human-computer dialogue. These issues are primarily cognitive issues, and thus the focus of software evaluation deals mostly with cognitive evaluation. This chapter will investigate in detail methodology that will be used in this research in the evaluation of ArcView-GIS. It also examines methods of data collection and the role-players who were consulted during the data collection stages.

3.2 Methodology

The evaluation process detailed in this chapter describes the evaluation of ArcView-GIS at the implementation phase. According to the evaluation framework proposed by Bain (1999), the focus of evaluation at this stage is summative and aims to establish the educational appropriateness of the product and whether the learning outcomes are as intended. The methodology is determined from peer review, formative monitoring of student involvement and experiences with the environment, and student learning outcomes. In order to do this it is necessary to collect data from a number of sources, generally using different methods. The data collected will be validated by “triangulation” and “bracketing” methods. Triangulation refers to the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings. According to Reeves and Hedberg (2003) triangulation derives from surveying, where it refers to the use of a series of triangles to map out an area. Bracketing on the other hand means “using multiple measures to provide a range of estimates of the value of a variable” (Reeves and Hedberg, 2003). “Triangulation” and “bracketing” methods has a subtle but important difference. The method used forms what may be termed an eclectic mixed-methods pragmatic paradigm as described by (Reeves and Hedberg, 2003). The method allows for a “mixed approach to data production and analysis, with

both qualitative and quantitative information obtained in the evaluation process” (Reeves and Hedberg, 2003).

Reeves and Hedberg (2003) identified four paradigms of research that include the Analytic-Empirical-Positivist-Quantitative Paradigm (AEPQP), Constructivist-Hermeneutic-Interpretive-Qualitative Paradigm (CHIQP), Critical Theory-Neomaxist-Postmodern-Praxis Paradigm (CTNPPP) and the Eclectic-Mixed Methods-Pragmatic Paradigm (EMMPP).

The AEPQP rests on the belief in a separate material reality, which can be objectively measured and explained through controlled experimentation. This paradigm has been criticized on the grounds that it is difficult to set up controlled conditions, it is possibly unethical and the tests themselves may be unrepresentative of important learning outcomes (Reeves and Hedberg, 2003). It is a quantitative strategy. It is concerned with proving or disproving a hypothesis, not on how a phenomenon occurred.

The CHIQP offers an alternative approach for investigating complex social processes, without resorting to a single viewpoint or mathematical model (Reeves and Hedberg, 2003). The interpretive nature of this paradigm means that such approaches are concerned with human observation and qualitative methods. It differs from AEPQP about the nature of reality from those of proponents of the quantitative paradigm. CHIQP has been criticized for producing findings that are too subjective, lacking in generalisability or being too difficult to produce (Reeves and Hedberg, 2003).

The CTNPPP emerged as an alternative to the reductionist view of the positivist paradigm and the subjective views of interpretivist paradigms and focuses on action, rather than analytical modeling or description (Reeves and Hedberg, 2003). The CTNPPP condemn the AEPQP as reactionary and criticize the CHIQP as unengaged. The CTNPPP put its emphasis on criticism and deconstruction. The Neomaxist faction of this paradigm view themselves as the forces of liberation engaged in an on-going conflict with the powers of oppression (Reeves and Hedberg, 2003).

The EMMPP uses multiple methods in evaluation “where its strength lies in its openness to borrowing the methods of the other three paradigms to collect information and solve a problem” (Reeves and Hedberg, 2003).

Paradigms are meaningful only within the context of their use and one approach is not necessarily preferable to another when it comes to particular problem-solving requirements. In EMMPP the focus is on practical problems rather than on issues of reality and theories of society. It acknowledges the weakness of current evaluation tools, and is more capable of handling the complexity of human learning and provides a variety of qualitative and quantitative strategies/techniques and approaches (yielding a variety of quantitative and qualitative data) (Reeves and Hedberg, 2003). The EMMPP approach is more capable of handling the complexity of modern society and technology, and the EMMPP strategy is recommended because it works better than other paradigms (Reeves and Hedberg, 2003).

3.3 Evaluation

The software was examined in three ways: (i) Through an assessment of students’ performance, by administering a specially designed test, comparing students who had used the program with those who had not; (ii) By canvassing the subjective opinions of students and instructors about the program by means of a specially designed questionnaire, interviews; and (iii) Through expert assessment of the software.

Therefore, this multi-faceted approach ensures that a broad view is taken during the evaluation, and establishes the educational appropriateness of the product, that is whether the learning outcomes are as intended.

3.4 Assessment of students’ performance

Altogether, seven sets of realistic scenarios were devised. These made use of drawings, angles, and language to describe an operational problem. Students were required to solve

problems based on these scenarios, using paper and pencil. During assessment, each student completed all scenario problems. The assessment was controlled in all groups so that no student encountered any problem. Students who had used the program were compared with others who had not used the program. This allows the author to look at the effect of using the program on students' performance. ,

3.5 Assessment of ArcView-GIS

Students who are familiar with the system were asked to complete a questionnaire aimed at eliciting their views of the software in terms of its effectiveness, the level of interest in use, human computer interaction, cognitive development, and overall subjective rating. The questionnaires used appear in Appendix 1 at the end.

ArcView-GIS experts at the University of KwaZulu-Natal were also used in the assessment of ArcView-GIS. It is also important to view the software from the user's perspective, as a complete integrated, functional experience.

ArcView-GIS was evaluated in terms of meeting its aim in terms of its functions. In the research process, it is highly unlikely that the necessary data will be found in only one of these sources. More often, the relevant material is compiled from several different sources, in order to obtain a better understanding of the subject under study. Two types of data sources can be used, namely, primary sources and secondary sources (Fig. 3.1).

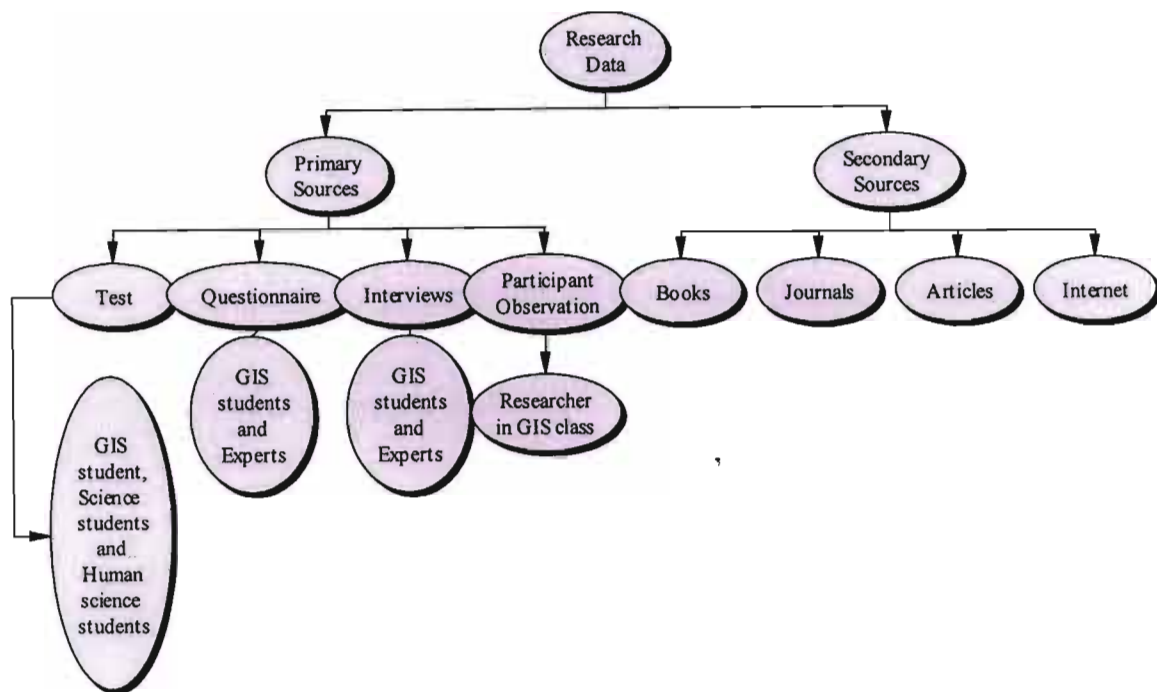


Figure 3.1: Data collection methods.

3.6 The sample

The sample used in this evaluation consisted of students doing their 3rd year in Faculty of Humanities (n=30); students their doing their 3rd year in Faculty of Science (n=30); GIS participants with no ArcView-GIS experience (Pre ArcView-GIS) (n=20) and those with ArcView-GIS experience (Post ArcView-GIS) (n=20) and lecturers from Geography department (n=3). The three lecturers had different academic profiles. Two lecturers were junior lecturers as they had bachelors or Masters Degrees, the other was a senior lecturer with a PhD degree and more experience. The pre-ArcView-GIS student, were students which were doing GIS in 2005 before being exposed to ArcView-GIS.

The study did not necessitate a larger sample on the ground that each participant had received the sample treatment over the same period of time and under similar, if not, identical settings. It was also felt that a larger sample would have involved frequency counts, resulted in non-response, and would have biased the results. Furthermore, the large frequency counts may lead to unwarranted generalizations not intended in this study. Taking a small sample also meant narrowing the focus of the study in order to

investigate whether the knowledge, skills and attitudes of the participants changed after using ArcView-GIS.

Participants were informed about the purpose of the research, the way data would be collected, and the various phases of the research study.

3.7 Instruments

Effectiveness data can be derived from questionnaires, interviews, observations and other methods. The effectiveness of ArcView-GIS was evaluated in the following categories: skills, knowledge and attitudes.

According to Reeves (1998) knowledge takes many forms. Most knowledge is conceptual in nature. The meaning of knowledge is changing. The change of meaning of knowledge has implications for how effectiveness evaluations are conducted (Reeves and Hedberg 2003).

The skills are also different. Skills are generally regarded as being more important knowledge.

The attitude includes factors such as motivation, moral values and prejudices. Sometimes people are purposefully deceitful in reporting attitudes but more often they just do not know how they feel or are unable to express their attitudes.

3.8 Secondary sources

Data collected using the secondary sources comprises textbooks, magazines, newspaper articles and handbooks. The advantages of using secondary sources include that less cost and less time is used than in primary research investigation. In this study, secondary sources of information are utilised primarily in the construction of a conceptual framework, which will be used to provide background information on the study. The information collected was from the following sources: books, journal articles, reports/documents, maps and the internet.

3.9 Primary sources

Primary sources are the major component of research, and may take various forms. They are original works of research or raw data without interpretation. In order to answer the research questions and attempt to present the position to be investigated, an “Evaluation Matrix” tool was used to help in choosing the most appropriate and feasible data collection method for each of the questions identified in this evaluation project. After using an evaluation matrix tool, the selected evaluation data collection methods were personal observation, questionnaires, interviews, a test and records. When the primary sources are used, they should reflect truly representative information for research (Reeves 1997). Where a data collection tool is relevant for a particular question, there is a cross in the relevant cell of the table (Table 3.1).

Table 3.1: Research Matrix

Method Questions	Questionnaires	Interviews	Observation	Test
Did students change in knowledge, skill and attitudes after finishing the GIS course?	X	X	X	X
Does ArcView-GIS provide a user-friendly interface for learners to engage with GIS knowledge?	X	X		
Does ArcView-GIS meet its aim in terms of its functions?	X	X		

3.10.1 Observation

Observational data is attractive as they afford the researcher the opportunity to gather live data from live situations. The researcher is given the opportunity to look at what is taking place in situ rather than at second hand (Patton 1990). This enables researchers to understand the context of the programmes, to be open-ended and inductive, to see things

that might otherwise be unconsciously missed, to discover things that participants might not freely talk about in interview situations, to move beyond perception based data (e.g. opinions in interviews) and to access personal knowledge. Morrison (1993) argue that observations enables the researcher to gather data on (i) The physical setting e.g. physical environment and its organization; (ii) Human setting e.g. the organization of people, the characteristics and make up of the groups or individuals being observed, for instance gender, class. (iii) The interactional setting (e.g. the interactions that are taking place, formal, informal, planned, unplanned, verbal, nonverbal act); (iv) The programme setting (e.g. the resources and their organization, pedagogic styles, curricula and their organization).

Observation can be conducted in an informal or a highly structured way. In a structured observation a set of tasks is set and the performance of the users is observed. A check list of points for observation may be drawn up beforehand. The performance of the user on the system is recorded against this check list. Informal observation in the field is often conducted to assess system acceptability. This is a useful general check. As researcher, the author was in an ideal position to collect this kind of information. Many informal discussions with students during and after their time on the GIS Practical were held. Observation was aimed to discover the behaviour of students in the context of their everyday living experiences personal observation was recorded and related to the research proposal. An informal observation was carried out by the researcher in University of KwaZulu-Natal (Howard College) in the GIS laboratory, and lecture venues during the GIS practical and lecture sessions. The observation period fell over fifteen weeks, from the 17 February 2003 to 26 May 2003.

3.10.2 Interviews

Interviews are powerful tools for collecting data about the effectiveness of software. They are a useful way to gain a rich understanding of users' reactions to a system (Reeves and Hedberg, 2003). Interviews were conducted with the lecturers, technician and students of the GIS course after spending some time working with the ArcView-GIS

software. All the interviews took place at the GIS department and in agreement with participants to record the conversation verbatim. Four GIS students and the three lecturers from GIS department were interviewed. Each participant took about 30 minutes to interview, depending on how much they could chat about ArcView-GIS experience. The responses were important because they gave views about whether students felt there were changes in their skills, knowledge and attitudes after using ArcView-GIS.

Interviewing is an effective research tool for collecting information and opinions (Brewerton and Millward, 2001). It is a face to face interpersonal role situation and relies on the research question being asked. Unlike questionnaires, which have a set of fixed questions and responses. The explanatory power of interviews can therefore be unlimited. The advantages of interviewing are flexible, rich data, and co-operation. The disadvantages of interviewing are that it can be time-consuming, costly, and open to bias. Brewerton and Millward (2001:69) describe three types of interviews: (i) **Structured interviews** involve a prescribed set of questions which the researcher asks in a fixed order. This method ensures rapid data coding and analysis, and guaranteed coverage of the area of interest (Brewerton and Millward, 2001). (ii) **Unstructured interviews** allow the researcher to address any of a given number of topics, which may be of interest to the research. Questions and their order are not fixed and may evolve during the interview process (Brewerton and Millward, 2001). (iii) **Semi-structured interviews** incorporate elements of both quantifiable, fixed-choice response and the facility to explore and probe in more depth certain areas of interest (Brewerton and Millward, 2001).

In the context of this study, semi-structured interviews have been undertaken by the researcher because of its advantages as stated above (see Appendix 2).

3.10.3 Questionnaires

Questionnaires are one of the most frequently used methods of collecting effective data. These responses are important as the knowledge, skills, and attitudes of students (cognitive development) after using ArcView-GIS in GIS course and user-friendly interface for learners to engage with GIS knowledge is being researched.

A questionnaire is probably the most commonly used tool within the social sciences (Brewerton and Millward 2001). It is a printed list of questions which respondents are asked to answer. Low cost, minimal recourse requirements and potentially large sample capturing abilities make questionnaires an attractive research option. A questionnaire is usually standardized, and is an indispensable tool when primary information is required about people, their behaviour, and opinions. The sampling design of the questionnaire generally includes random sampling, systematic sampling, stratified random sampling, and cluster sampling.

Most questionnaires require respondents to provide some background information relating to themselves, race, and educational level. But questionnaires used in this research required respondent to provide two types of information namely Human Computer Interaction which requires respondents to provide information relating to ArcView-GIS software. The second part of the questionnaire requires respondent to provide cognitive development information i.e. skills, knowledge and attitudes gained from ArcView-GIS software.

3.10.4 Tests

Testing is also accepted as an effectiveness evaluation strategy. The purposes of a test are several, for example to diagnose a student's strengths, weaknesses and difficulties, to measure achievement, to measure aptitude and potential, to identify readiness for a programme. Tests are normally designed to discover whether students have the essential prerequisites to begin the programme e.g. in terms of knowledge, skills, understandings. The type of test which is used in this project takes two forms. It is a diagnostic test and a summative test. Diagnostic testing is an in-depth test to discover particular strengths, weaknesses and difficulties that a student is experiencing, and is designed to expose causes and specific areas of weakness and strength. It is a criterion-referenced.

The summative testing is the test given at the end of the programme, and is designed to measure achievement, outcomes, or mastery. This might be criterion referenced or norm-

referenced, depending to some extent on the use to which the results will be put (e.g. to award certificates or grades, to identify achievement of specific objectives).

The kind of test which will be used is short answer, true-false, simple multiple choice, and complex multiple choice. Like any other method, a tests method has its own advantages and disadvantages in terms of acceptability, feasibility, reliability, validity and security. A paper-pencil test was conducted. This paper-pencil test requires the students from Faculty of Humanities, Faculty of Science and GIS to demonstrate the knowledge, skills/ or attitudes they possess. The test method helped to test whether ArcView-GIS contributed to students cognitive development. According to Reeves and Hedberg (2003) it is more difficult and expensive to use performance tests, but the validity of this method is usually high. The literacy and communication research instruments were taken from skills assessment tools designed by Foko (2003) (Appendix 3).

3.11 Conclusion

Data collected from participant observation, questionnaires and interviews are presented separately in chapter 4. Collection of data plays a very significant role in moving forward the research. Data analysis can produce new insight and information by careful description which will form the basis for evaluation and recommendations to be made. In the collection of data from the participant, confidentiality was assured. Participants had an option of quitting at any stage.

In the analysis of data, specialised software packages for quantitative and qualitative data analyses were used namely SPSS (SPSS Inc) for quantitative analysis and QSR NVivo for qualitative analysis.

CHAPTER 4 – RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and analyses the research findings. An important part of this study is to summarise and evaluate these results according to different criteria as well as to make recommendations.

Numerical analyses were conducted using SPSS (SPSS Inc). In most cases, the comparison of mean and box plot (see Fig. 4.1) are used in the analysis of data.

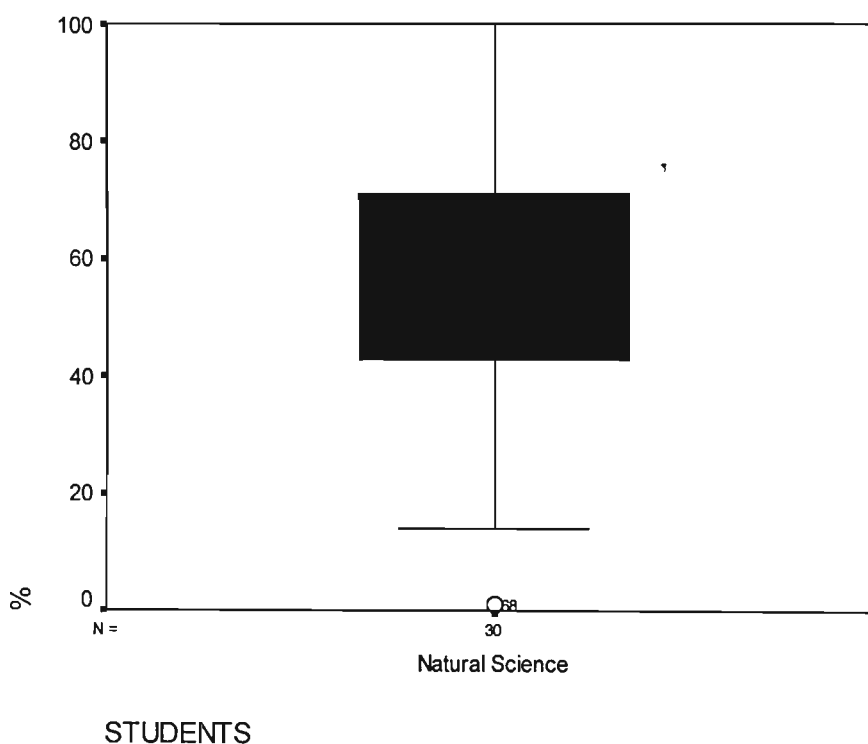


Figure 4.1. An example of a box plot.

A **box plot** (also called a box-and-whiskers plot) is a visual representation of the “spread” summary of a set of data. Box plots allow you to focus on the relative positions of different sets of data and thereby compare them more easily.

According to NetMBA.com (2005) a box plot is interpreted as follows:

- The box itself contains the middle 50% of the data. The upper edge (hinge) of the box indicates the 75th percentile of the data set, and the lower hinge indicates the 25th percentile. The range of the middle two quartiles is known as the inter-quartile range;
- The line in the box indicates the median value of the data;
- If the median line within the box is not equidistant from the hinges, then the data is skewed;
- The ends of the vertical lines or "whiskers" indicate the minimum and maximum data values, unless outliers are present in which case the whiskers extend to a maximum of 1.5 times the inter-quartile range; and
- The points outside the ends of the whiskers are outliers or suspected outliers.

NetMBA.com (2005) states that beyond the basic information, box plots sometimes are enhanced to convey additional information:

- The mean and its confidence interval can be shown using a diamond shape in the box;
- The expected range of the median can be shown using notches in the box; and
- The width of the box can be varied in proportion to the log of the sample size.

4.2.1 Participants

A number of different groups participated in this study and include participants from Human Science (n=30), Natural Science (n=30), and GIS participants with no ArcView-GIS experience (Pre-ArcView-GIS) (n=20) and those with ArcView-GIS experience (Post ArcView-GIS) (n=20) .

4.2.2 Results

2-Dimensional Visualization Skills Assessment

Nine questions (Fig. 4.2) were used to determine the 2-D visualization skills of learners who 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. Participants with GIS experienced outperformed

Human Science, Natural Science faculties and GIS students with no ArcView-GIS experience. GIS student scored 84.5%, students from Human Science scored 53.3%, Natural Science students scored 70.9% and GIS students with no ArcView-GIS experience scored 53.4%. The overall mean for this section was 64.9%.

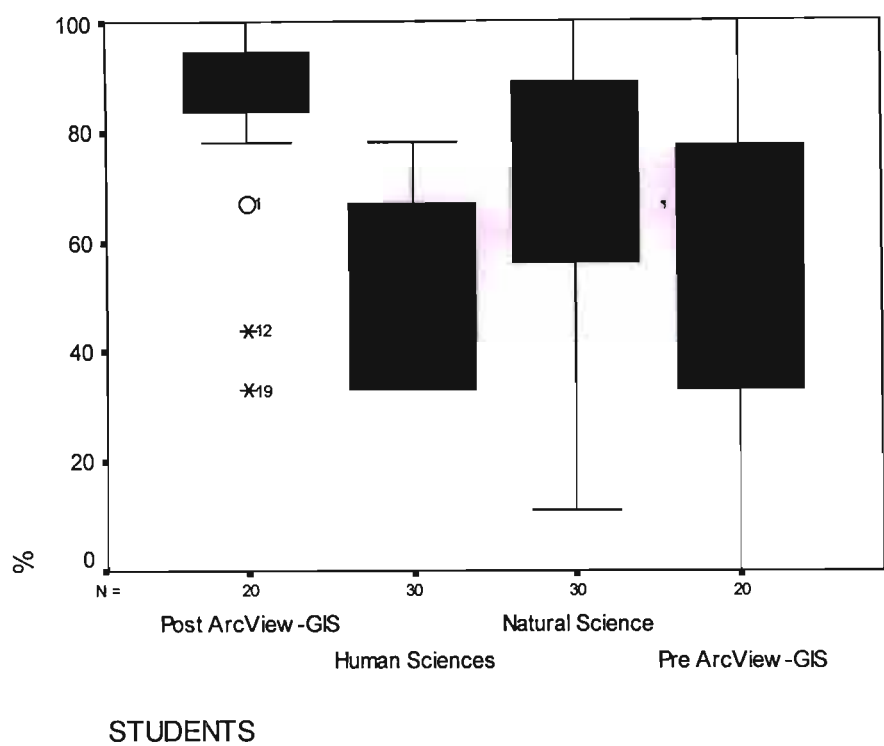


Figure 4.2. Box plot displays of the 2-dimensional visualization skills assessment of GIS, Human Science and Natural Science students.

3-Dimensional Visualization Skills Assessment

Fourteen questions were used to determine the 3-D visualisation skills of learners (Fig. 4.3). These exercises required the matching of similar figures viewed from different angles. Still in this section GIS students outperformed the Human Science and Natural Science faculties. GIS student scored 80.9% students from Human Science scored 48.4%, Natural Science students scored 71.1% and GIS students with no ArcView-GIS experience scored 63.5%. The overall mean for this section was 64.7%

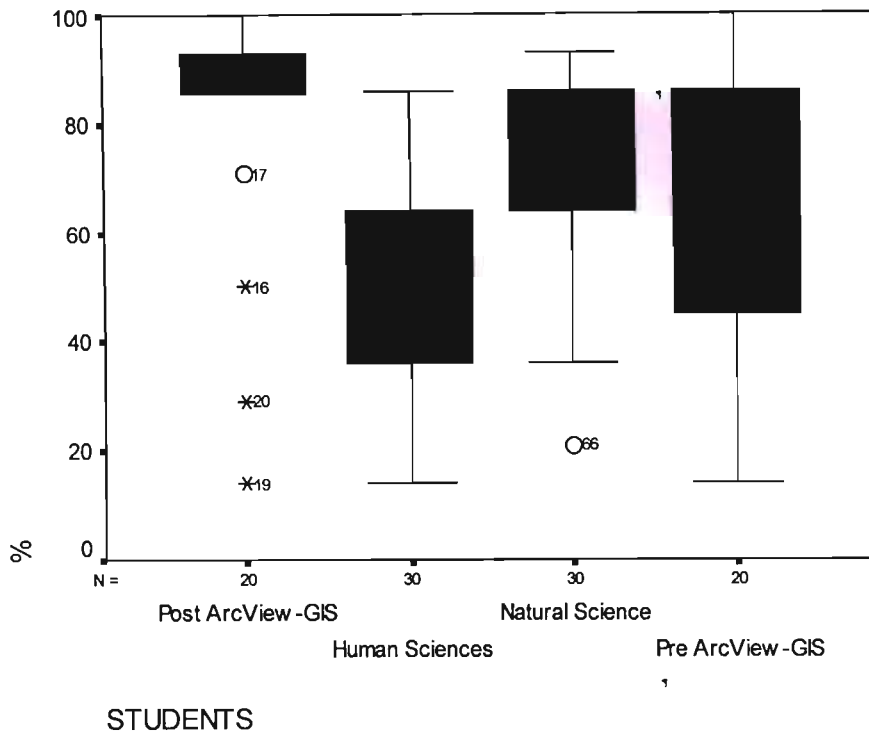


Figure 4.3. Box plot displays of the 3-dimensional visualization skills assessment of GIS, Human Science and Natural Science students.

2-D to 3-D Visualization - Folding Metal Sheets - Assessment

Seven questions were used to evaluate learner 2-D to 3-D visualization skills where they had to mentally fold, along the perforated lines, flat objects made from pieces of metal or cardboard into 3-D objects (Fig. 4.4). In this section the overall mean dropped to 55.5 still GIS student outperforming the other faculties i.e. Human Science, Natural Science students GIS students with no ArcView-GIS experience. GIS students scored 74.9%, while Human Science scored 48.2%, Natural Science students scored 51.9% and GIS students with no ArcView-GIS experience scored 52.7%.

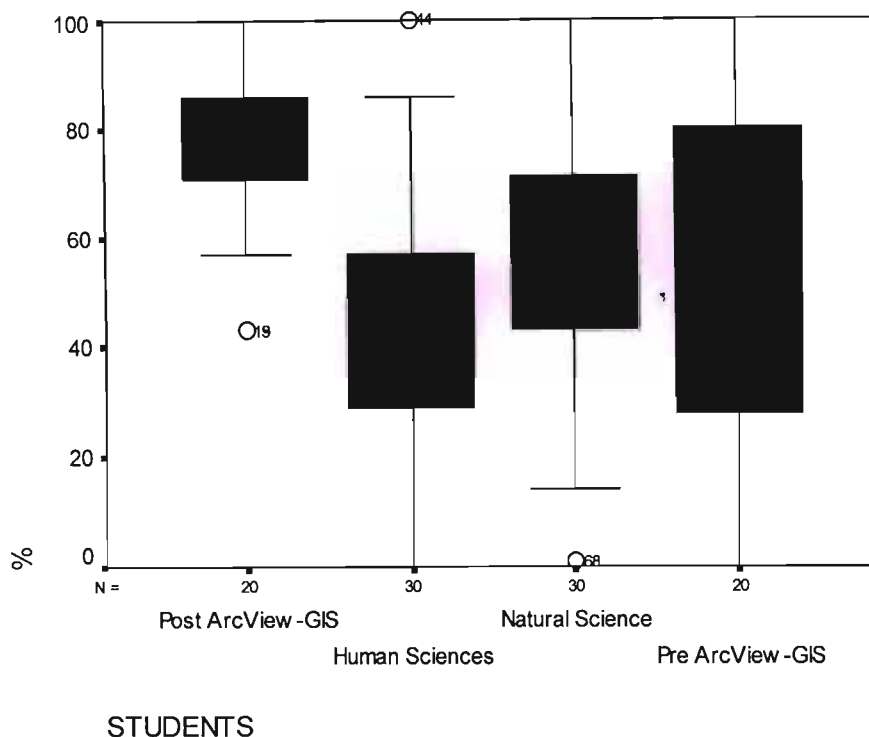


Figure 4.4. Box plot displays of the 2-dimensional to 3-d visualization skills assessment of GIS, Human Science and Natural Science students.

Logical and Numerical Skills Assessment

Thirty questions were used to assess the learner's ability to logically discern numerical and word patterns and to apply them to new contexts. Participants achieved an overall mean of 63.3% for this section. With the exception of GIS participants, with a mean of 86.5%, Human Science participants averaged less than 50%, but Natural Science students scored 67.4% and GIS students with no ArcView-GIS experience scored 59.8%. (see Fig 4.5).

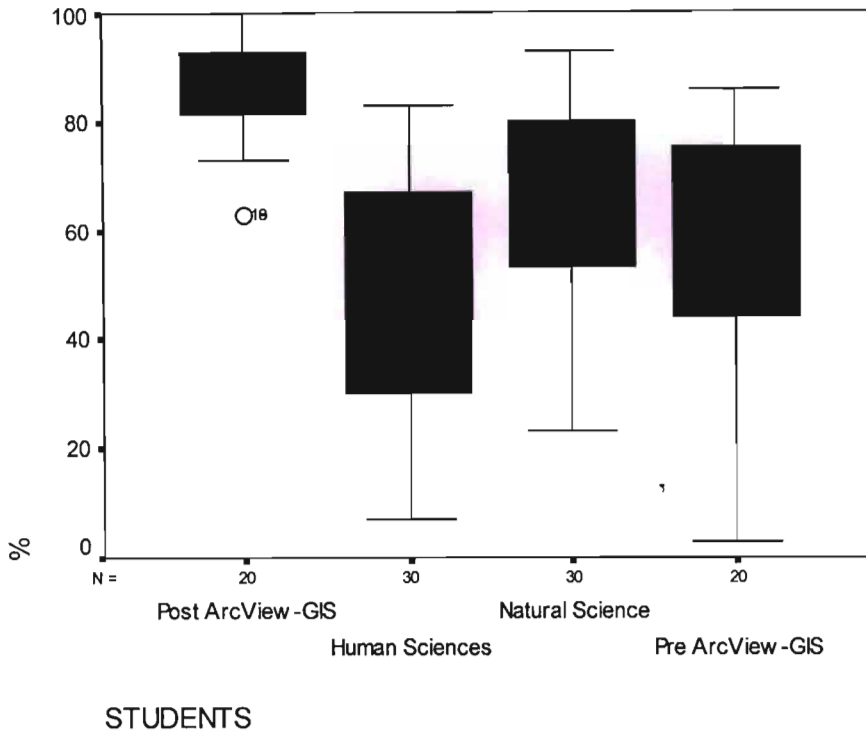


Figure 4.5. Box plot displays of the logical and numerical skills assessment of GIS, Human Science and Natural Science students.

Structuring Sentences Assessment

Questions 1 to 4 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. In structuring sentences assessment, the students achieved 75.5% overall mean, with Human Science students averaging 59.2%, Natural Science scoring 76.7%, GIS students with no ArcView-GIS experience scored 76.3% and GIS students outperforming all the other participants by 97.5% (see Fig 4.6).

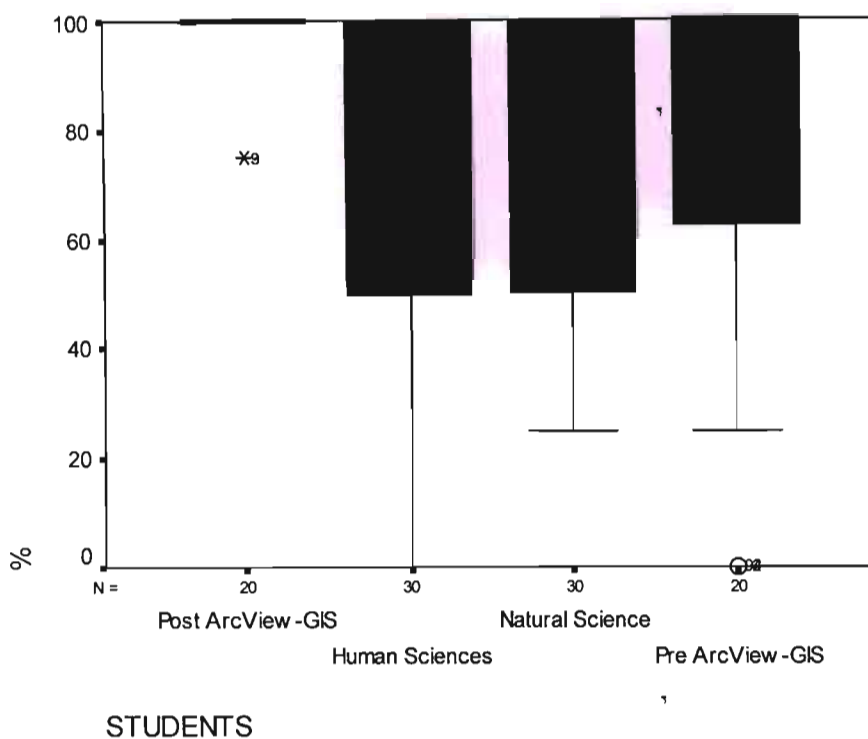


Figure 4.6. Box plot displays of the sentence structuring skills assessment of GIS, Human Science and Natural Science students.

Written Expressions Assessment

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 (see Fig. 4.7). The overall mean for this section was 76.8%. Again, GIS students outperformed the other students. The GIS students scored 94.9% while Human Science students scored 67.1%, Natural Science students scored 74.4% and GIS students with no ArcView-GIS experience scored 77%.

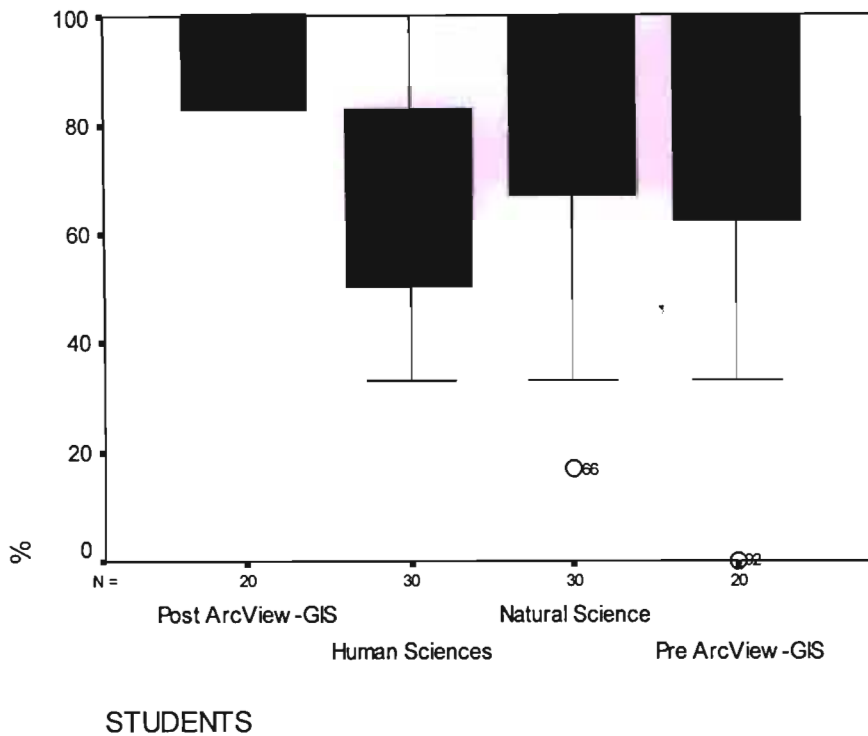


Figure 4.7. Box plot displays of the written expression skills assessment of GIS, Human Science and Natural Science students.

Reading Comprehension Assessment

In this part of the test ten questions were used to measure learners' ability to read and understand short passages similar in topic and style to those found in tertiary institutions. Learners read a passage followed by a number of questions related to the passage (see Fig 4.8). The overall mean for this section was 73.5%. Again GIS students outperformed the other faculties. GIS students scored 96.5%, Human Science scored 64.3%, Natural Science scored 74.3% and GIS students with no ArcView-GIS experience scored 63%.

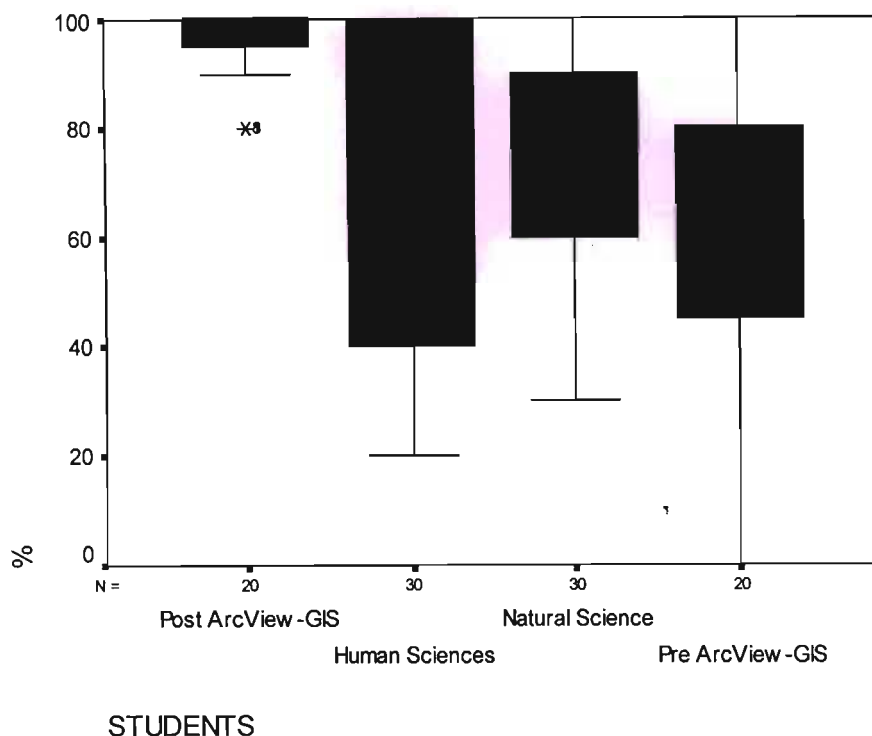


Figure 4.8. Box plot displays of the reading comprehension skills assessment of GIS, Human Science and Natural Science students.

The most important results are those that reveal differences in student's performances as a result of using the ArcView-GIS software. The differences between GIS students and Human Science together with Natural Science students, are very clear-cut: the scatter plot graph shows the comparison of students from GIS, Human Science and Natural Science performance in coursework mark and skills test.

Scatter plot graph (Fig. 4.9) shows the relationship between two variables by displaying data points on a two-dimensional graph. They provide information about the relationship between two variables: strength, shape –linear, curved etc, direction –positive or negative, presence of outliers (NetMBA.com, 2005).

The results revealed that GIS students have a significant difference between their coursework mark and skills test. In their skills test they scored 89.9% and scored 65.7% in their coursework. The software was clearly effective in improving student's

performance, if taking into cognisance the great difference of skills test vs. coursework mark of GIS student and the GIS skills test scores vs. Human Science and Natural Science skills test scores.

Human Science students in their skills test scored 59% and in their coursework marks scored 60.7%. The score revealed no significant difference in skills test and coursework scores in Human Science students. Natural Science students scored 62.5% in their coursework marks and scored 69.8% in the skills test.

These results clearly indicate that while the GIS students performed much better in skills evaluation, the performance in normal course work was not different from the other groups.

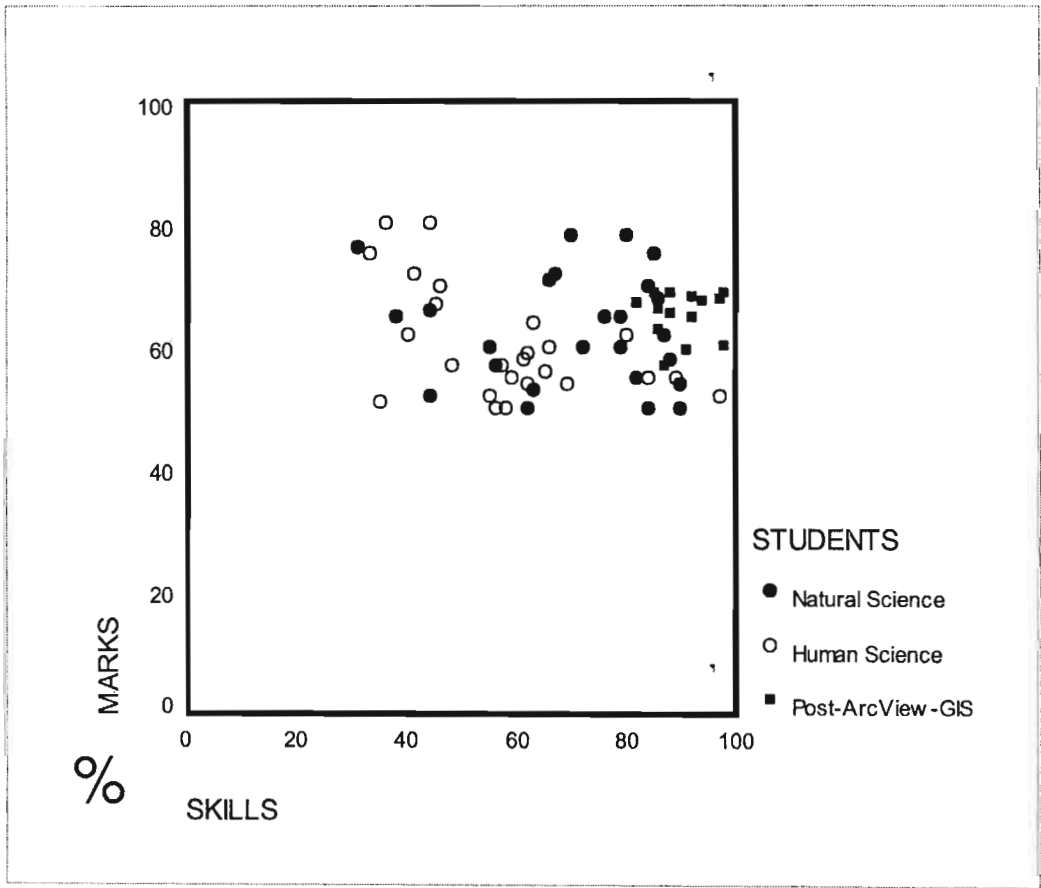


Figure 4.9. The scatter graph shows the coursework mark and skills test scores of Natural Science, Human Science and GIS students.

4.3.1 Questionnaire

In analysis of data from Human Computer Interaction and Cognitive Development Questionnaire, descriptive statistics was used in SPSS (SPSS Inc). Twenty students and three lecturers from GIS department completed the questionnaires (see Appendix 1).

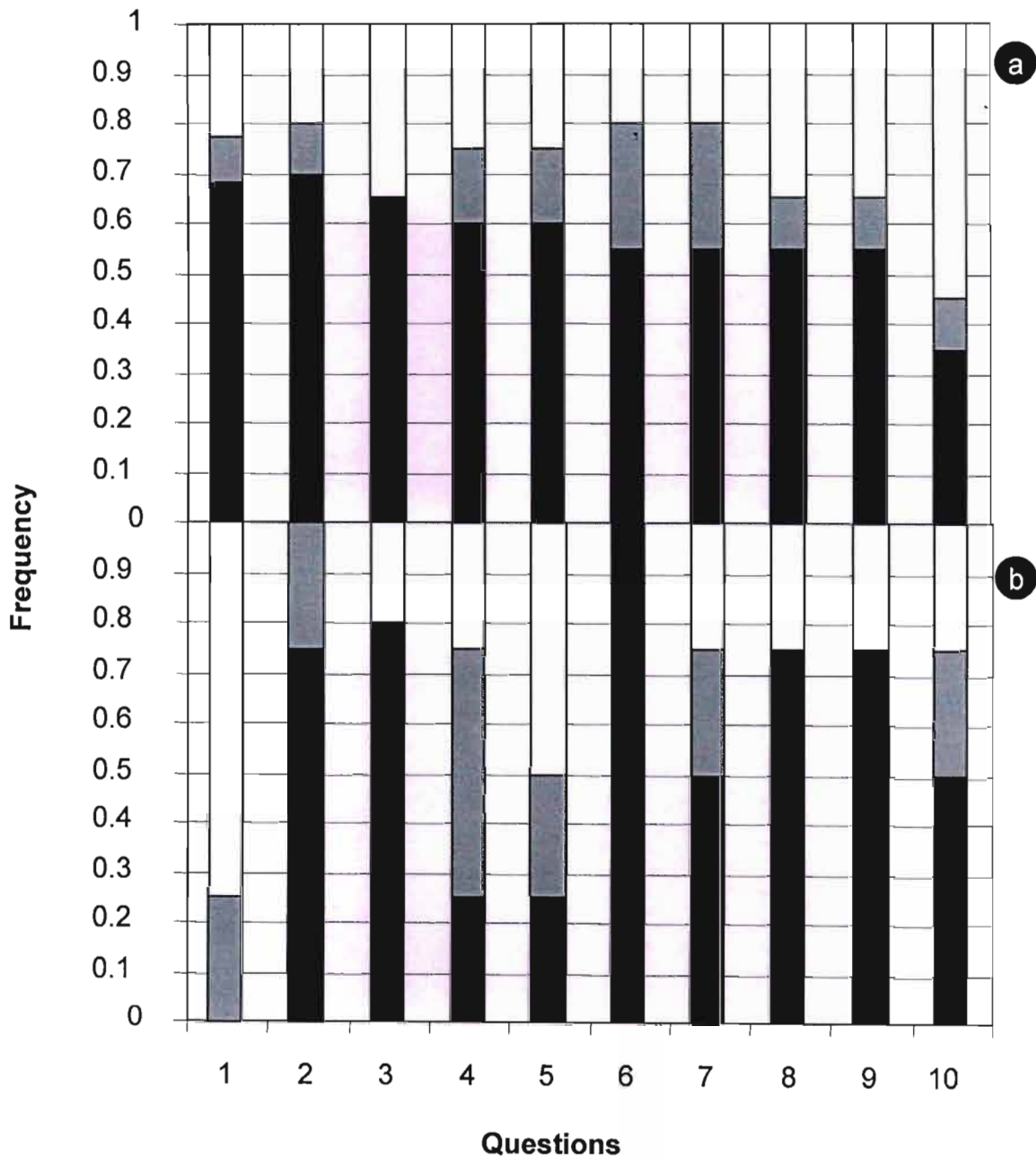


Figure 4.10. Bar graph showing lecturers (a) and students (b) responses related to HCI questions (■ - Strongly agree plus agree; □ - Neutral; ■ - Disagree plus strongly disagree).

The specific HCI and cognitive development attributes that were investigated in order to establish the participants' perception of the HCI of ArcView-GIS, included general usefulness/utility, effectiveness and efficiency, reliability, ease of use, error management, consistency and compatibility, learnability and user satisfaction. The following section will provide a short overview of the questionnaire results shown in the bar graphs figures 10 and 11 as it pertained to the participants' perception of the HCI and cognitive development of ArcView-GIS.

Firstly results related to Fig. 4.10 are discussed:

Question 1

The students and lecturers have different views on visibility of ArcView-GIS status. Most of the students agreed that the ArcView-GIS always keep them informed about what is going on through appropriate feedback within reasonable time, but most of lecturers disagreed. The visibility of the ArcView-GIS status referred to the degree to which a product enables a user to achieve his or her goals and is an assessment of the user's motivation for using the product.

Question 2

The response by both students and lecturers to the language used to label screen information (i.e. user interface) is simple and familiar to the user was significantly positive. This response indicates a good screen layout with effective use of fonts and colour. The implication is that the screens are legible and easy to follow. No significant navigation problems were indicated.

Question 3

A positive response was also recorded by both the students and lecturers to the ArcView-GIS capabilities, which indicates that the ArcView-GIS allow users to easily correct, or recover from, mistakes or errors.

Question 4

The majority of the students regarded the ArcView-GIS as easy to use, while the majority of the lecturers were neutral. Few lecturers were positive about the ArcView-GIS. Ease of use referred to the effortlessness and user-friendliness of the system.

Question 5

The majority of the students agreed that the ArcView-GIS are *consistent and compatible* while the majority of the lecturers were neutral. Few lecturers were positive about the ArcView-GIS. Consistency referred to the ability of the ArcView-GIS to respond to user inputs in a consistent way and to perform similar tasks in similar ways. Compatibility referred to the degree to which the system's method of operation matched with the user's expectations.

Question 6

All the lecturers agreed that ArcView-GIS is reliable. However a few students disagreed. Reliability referred to the dependability of the system and the repeatability, without failure, of completing tasks while using the system.

Question 7

Both the students and lecturers agreed that the ArcView-GIS was flexible and effective of use. There were few students and lecturers which were natural and disagreed with the students. Flexibility and efficiency of use referred to that the ArcView-GIS can cater both inexperienced and experienced users.

Question 8

More lectures than the students agreed that the ArcView-GIS was aesthetic and minimalist in design. Few lecturers and student disagreed with the statement. Aesthetic and minimalist design referred to that the ArcView-GIS did not offer more than is required for the user to perform a task, but it was aesthetically pleasing.

Question 9

Also more lectures than the students agreed that the ArcView-GIS had error messages which were useful. There were few lecturers and students who disagreed and few students who were neutral. Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Question 10

The students and lecturers have different views that it is easy to find, or search for, information provided by ArcView-GIS. Most lecturers were positive, while students were not.

We can conclude that the users judged the ArcView-GIS to be well design and suitable for its purpose.

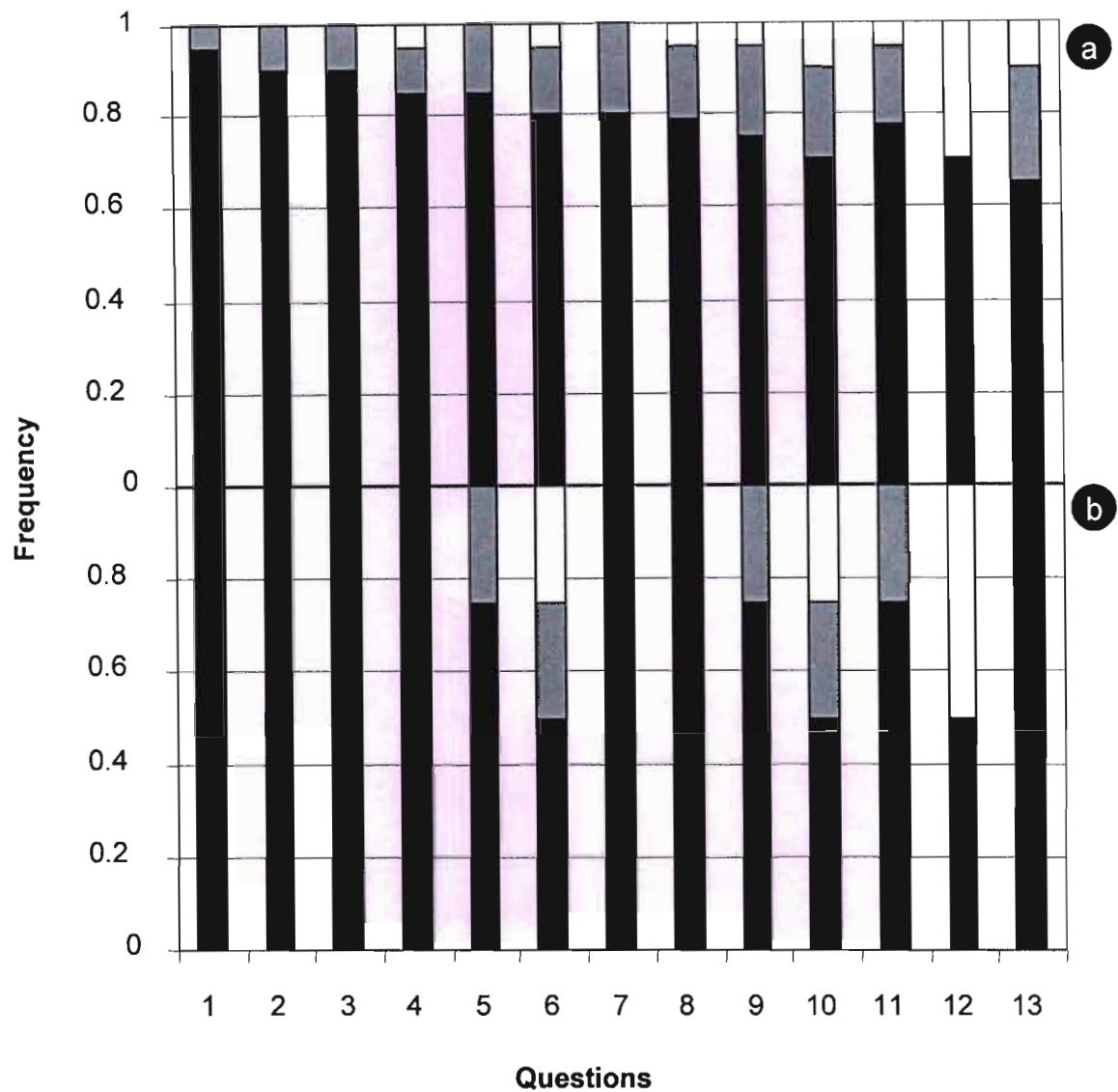


Figure 4.11. Bar graph showing lecturers (a) and students (b) responses related to cognitive development questions (■ - Strongly agree plus agree; □ - Neutral; ▒ - Disagree plus strongly disagree).

As can be seen from the graph in Fig. 4.11 from question 1 to 5, the overall reaction of the users, both students and lecturers was positive. The implication is that users found ArcView-GIS to be effective, interesting, of sufficient length and teaching adequate skills. The major skills that students and lecturers gained in using ArcView-GIS are as follows:

- **Research Skills:**

- Determining the nature of the problem and how research should be organized.
- Searching for information using text, electronic and pictorial information sources.
- Analyzing and interpreting all the information collected to identify and interpret patterns

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- Searching for information using text, electronic and pictorial information sources.
- Analyzing and interpreting all the information collected to identify and interpret patterns.

- **Presentation Skills**

- Mapping the design onto the presentation and implementing the ideas.
- Attracting and maintaining the interests of the intended audiences.
- Improved visualization and spatial reasoning skills.

- **Organization and Representation Skills**

- Deciding how to segment and sequence information to make it understandable.
- Deciding how information will be represented (text, pictures, movies, audio, etc.).
- Deciding how the information will be organized (hierarchy, sequence) and how it will be linked.

- **Reflection Skills**

- Evaluating the program and the process used to create it.
- Revising the design of the program using feedback

An overall response was again positive in knowledge gained from question 6 to 10 by students in ArcView-GIS. Two negative aspects were that identified as not helpful.

Concept presented in the course and deeper understanding of geographical and environmental knowledge which lecturers felt that those aspects were not helpful. Students and lecturers agreed that ArcView-GIS helped them to gain a deeper understanding of geographical and environmental knowledge. The bottom line was that by establishing an environment where creative thinking about the content is combined with real-world assignment, students learned the content, enjoyed the learning process, and recognized that they had created something useful. Furthermore ArcView-GIS helped them to understand spatial, location, and geographical information. This study illustrates the principle that: "Cognitive tools empower learners to design their own representations of knowledge rather than absorbing knowledge representations preconceived by others" (Perkins, 1986).

There was a positive attitude towards ArcView-GIS by both students and lecturers agreeing that ArcView-GIS is a valuable learning experience. Furthermore they agreed that ArcView-GIS changed the way they perceived and interpreted maps. Except in question 12 where one lecturer disagreed saying ArcView-GIS did not made him change the way he viewed social and environment issues.

4.4.1 Interview

After obtaining information from tests and questionnaires, the task was to continue to discover as much as possible about the ArcView-GIS software. The adoption of the interview method is to enable the researcher to obtain a richer understanding through direct procedure, which would allow the interviewee more scope for elaboration and general discussion on the research issues. The interviews were conducted with three lecturers and five students, who volunteered, involved in GIS course. These semi-structured interviews provide qualitative information, which is based on their in-depth knowledge and experience relating to the study. This process entailed probing for substantial responses.

Interviews were undertaken during the research period, between the 12 and 13 October 2004. Each interviewee was asked the same questions (Appendix 2).

The data from interviews were imported into QSR NVivo, a qualitative data analysis software package; the qualitative data were analyzed via three techniques derived from grounding theory: coding, memo writing and the network display (Morse and Richards 2002). The coding phase of the analysis progressed in three stages (Glaser and Strauss 1990): open (i.e. broad coding of general themes), axial (i.e. a more refined coding of themes) and selective coding. For the memo writing analysis, memos were written at the initial reading of the transcripts and during all phases of analyses to highlight key questions about relationships in the data, to refine categories, and emerging analyses. In the networks display stage of analyses, codes were used to “network display” the data visually.

4.4.2 Validity of analyses

Qualitative theorists have proposed several criteria for judging the quality or trustworthiness of qualitative analyses (Miles and Huberman 1994). The quality of analyses was assessed via three criteria: credibility, transferability, and conformability (Lincoln and Guba 1985). First, the degree to which findings were credible was assessed by examining codes that supported key themes in the data. The goal of transferability is to assess whether the conclusions drawn from a qualitative study can be compared with other samples or theories. "Thick description" (Lincoln and Guba 1985) is provided to assist others interested in assessing the transferability of the study's findings. Thick descriptions include, but are not limited to, detailed accounts of the sample and discussion of prior theory. Finally, conformability refers to the extent to which the study's methods, procedures, process of data collection and analyses, and conclusions have been described thoroughly. Provided in the results section are quotes from participants to support the conclusions drawn. With the exception of some minor edits to improve clarity, all quotes are provided verbatim. To protect participants' confidentiality, I have provided pseudonyms and changed all occupations or other identifiers.

4.4.3 Results from interviews

Responding to an interview question about students changing in knowledge, skills and attitudes after finishing the GIS course, all the interviewees were positive about ArcView-GIS software, the three experts (lecturers from GIS) agreed that students developed cognitively after using ArcView-GIS software. One of the experts from GIS said “Students gained skills for calculations, steps or ways to follow when solving the problem. Students became familiar with maps and became able to design maps”. One of experts from GIS said “I have seen students applying arcView-GIS in other courses and student do improve in knowledge, skills and attitude”. A technician from GIS said “Yes students did change in knowledge because students were more capacitated after finishing the course. They gained skills e.g. analysing, reporting, accuracy of good data management. Students are also able to use the same skills they learned from arcView-GIS in other software’s. The students attitudes changed, for example they started to see how important is the arcView-GIS”.

Five students explained that “GIS is a good course. It helps people to understand concepts/ images on maps. It also helps to understand features spatially. ArcView-GIS generally provides a good platform of data management”.

The experts from GIS and students interviewed articulated a variety of themes about gained knowledge, skills and changed attitudes in ArcView-GIS namely skills gained, solving problems, analysing, presenting, analysing maps, reporting, data management, ArcView-GIS require computer literate, knowledge, learn through ArcView, mapping, design maps, show information, change in knowledge, computer literate,

A network display (Fig. 4.12) illustrates the common theme of cognitive development in GIS students. Computer literate, gained skills, data management, changed in knowledge, design maps, reporting, gained knowledge, analysing, show information, solve problems and attitude changed. A common theme in all the definitions of the above-mentioned codes is ways in which the students and experts speak about aspects of the cognitive development of GIS students. While reflecting on this network I realized that students

and experts agreed that ArcView-GIS promotes cognitive development in students studying a GIS course at the University of KwaZulu-Natal.

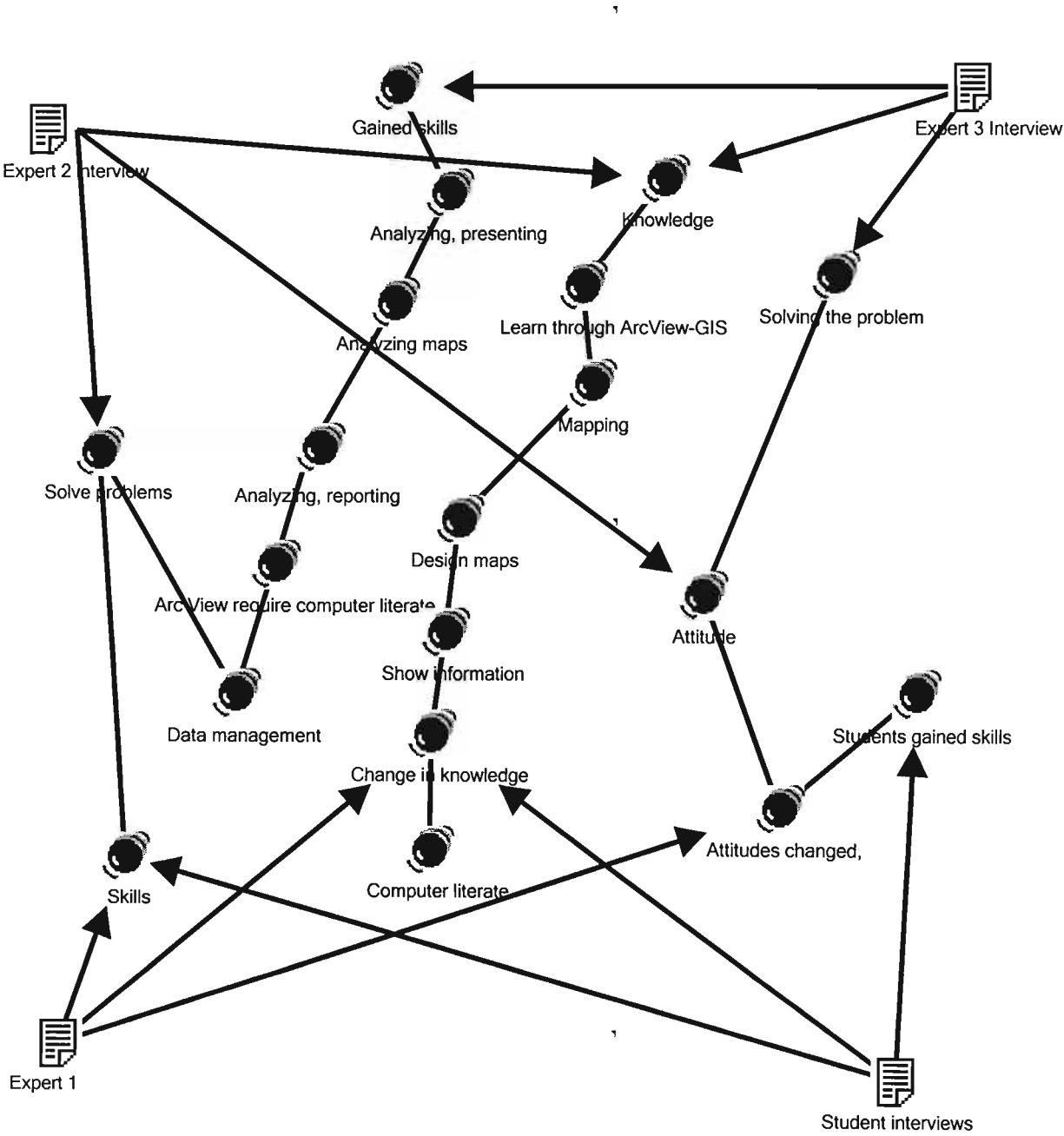


Figure 4.12. Cognitive development of GIS students derived by NVivo

4.5.1 Triangulation

In order to triangulate the findings, learners were observed as they worked on their projects until they made their presentations.

4.5.2 Observation of the students

I had the privilege of being a student with the participants (students) for three months. During this period I observed and got to know them so, that I was able to verify the data in the questionnaire, I witnessed the following in the GIS class during ArcView-GIS project sessions and practical sessions.

There was chatting that I witnessed among students during the practicals, which shows that the ArcView-GIS also promoted communication among the students.

I have also observed some negative aspects which were encountered by students regarding the ArcView-GIS: (1) The unstable error messages and difficulties to understand computer jargon caused frustration to students; (2) The lack of pre-requisite exposure to and familiarity with computers; and (3) The cost of ArcView-GIS which prevented students to have the software at home.

Students reported that the nature of ArcView-GIS contributed to their intrinsic motivation to progress.

The assignments required that students carry out tasks and activities in order to meet broadly defined course objectives. This gave students considerable choice and flexibility as to the specifics and details of the methods and materials that they used to meet the prescribed goals. In the process they became active learners, motivated to acquire the necessary skills to achieve the course objectives.

The ArcView-GIS project provided the opportunity for students to apply the new knowledge they had acquired through the assignments in immediate and practical ways.

Each learner identified a relevant problem to work on that could have real-life application in his or her work situation. During the three months they then monitored or solved and reported on the problem. This process enabled students to identify the value of their learning for themselves.

Students believed that the marks awarded to them were a fair reflection of their knowledge, skills and abilities after completing the course. Despite the possibility that the software did not influence learning there were other aspects which students thought were favourably influenced. Whether the GIS course results were among their best results or not, they all expressed enthusiasm about how much they had learnt and benefited from the ArcView-GIS, its approach and methodology.

Student expectations of what they would gain from the GIS course included the development of their knowledge and skills. They hoped to learn how to make better decisions and develop cognitively. After the course students reported that they had fulfilled these expectations. They referred to considerable academic, technical and social learning gains as a result of the GIS course.

4.6 Conclusion

The questionnaire survey was undertaken with the purpose of the research as a key means of obtaining information from the students and lecturers (experts). Each questionnaire took approximately five minutes to complete. The responses to the questionnaires were good and are consistent with the findings from the participant observation survey and interview survey. Some issues outside the questionnaire were also raised and commented on by the respondents, which can be seen as a contribution to this research. This survey therefore provided an important input to the research.

CHAPTER 5 – CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 Introduction

This study evaluates whether ArcView-GIS promotes cognitive development (i.e. spatial visual perception skills). In order to address the research problem, the following research questions were identified and examined:

- (1) Did students change in knowledge, skills and attitudes after finishing the GIS course?
- (2) Does ArcView-GIS provide a user-friendly interface for learners to engage with GIS knowledge?
- (3) Does ArcView-GIS meet its aim in terms of its functions?

This chapter concludes the research into the problem. The following section presents answers to the identified questions.

5.2 Answers to the research questions

1. Did students change in knowledge, skills and attitudes after finishing the GIS course?

The overall response of the students and lecturers using the ArcView-GIS was extremely positive and encouraging. Judging from the skills test and coursework mark for GIS students, there was the improvement in GIS students. According to the literature review ArcView-GIS has a positive impact on student in terms of skills, knowledge and attitudes. According to ESRI homepage (2004) ArcView-GIS improves problem solving skills and critical thinking skills such as analyzing, synthesizing, and evaluating, also students develop their spatial knowledge when using ArcView-GIS. Furthermore, the great difference of skills test vs. coursework mark of GIS student and the GIS skills test scores vs. Human Science and Natural Science skills test scores showed the that GIS students performed better meaning that ArcView-GIS had an impact on GIS students. Research by means of participatory observation, questionnaires and interviews at University of Kwazulu Natal has shown that ArcView-GIS have contributed in improving students' performance.

In a discussion on spatial visualization, Gardner (2004) believed the following to be most relevant to the skill of visualization:

“(1) The ability to hold and compare images using both 3D representations and multi-view representations of an object, (2) The ability to manipulate 3D objects within a 3D configuration (to rotate the object, (3) And the ability to deconstruct and manipulate these deconstructed components of a 3D object within a 3D configuration (unfolding and folding, sections, embedded figures) - interfering mentally with the integrity of a 3D object”.

Gardner (2004) argue that the “spatial functioning is a mental process which is associated with the brains attempts to interpret certain types of incoming information”. This information is basically anything visual - pictures, maps, plans etc. previously disadvantaged schools tends to produced students which performs poorly in special and visualization constructs and in 3-D problems and those characterized by special orientation constructs. This study found that most of the Human Science learners lacked the ability skills to comprehend the combination of rectangles, circles and the ability to visualize rearranged objects; GIS students performed better in combination of rectangles, circles and the ability to visualize rearranged objects, in questions related to 2-D visualization, 3-D visualization, 2-D flat sheets into 3-D objects. In every case GIS students outperformed students from Human Science and Natural Science in all the tests namely (1) 2-Dimensional Visualization Skills Assessment, (2) 3-Dimensional Visualization Skills Assessment (3) 2-D to 3-D Visualization - Folding Metal Sheets - Assessment (4) Logical and Numerical Skills Assessment, (5) Structuring Sentences Assessment (6) Written Expressions Assessment, (7) Reading Comprehension Assessment. Osondo (1999) found that that the students that lacked the skills of visualization improved the visualization skills with the increased exposure to visual objects and advances in their studies. Thomas and Higbee (1996) argue that educators need to include or incorporate a variety of methods in their techniques in the classroom to stimulate visualization skills in students (Gadner 2004),

I can conclude that the software is effective in consolidating and adding value to the existing cognitive development to students. The attitude assessment revealed that, on the whole software was popular with students and does not suffer from any major usability problems. Experience with the software has changed the way they perceive and interpreted maps. The software also made students to change the way they viewed social and environmental issues.

2. Does ArcView-GIS provide a user-friendly interface for learners to engage with GIS knowledge?

Response to this question was positive and negative. Some students and experts were positive about the user-friendly interface and some were negative. According to respondents in questionnaire and interviews, they found using ArcView-GIS as a valuable learning experience. Lecturers, who might be expected to be more critical than their students, also reacted favorably to most aspects of the software. Comments from a few users suggested that: (1) After making mistakes with a software it must able the user to undo many times; (2) The software must make the error messages clearer and more meaningful; (3) Also the software must use understandable jargon because not all geographers understand computer jargon; (4) Also they suggested that if speed can be improved it will be much better because sometimes; and (5) The software is too slow. Also, the software shuts down when too much data is inputted, this was frustrating to users. Literature review revealed that ArcView-GIS promotes using system customized to the students' prior knowledge and enhance student learning, ArcView-GIS is being designed with the philosophy and pedagogy reinforcing the inquiry-based approach to learning and it offers a collection of research-based inquiry technology, from probe, to Internet resources, all in an effort to support with the specific tools that researchers and students need. Also, it emphasizes hands-on problem solving. Literature review also revealed that ArcView-GIS present coherent patterns in the form of Graphic User Interface (GUI) that help learners remember events, ideas and relations between observations and derived inferences.

According to students and lecturers response in human computer interface response in Chapter 4, the overall ratings for students were positive (the sum of Valid Percent was 59%) and the overall ratings for lecturers were again positive, though less than with students (the sum of Valid Percent is 55). Furthermore drawing from participatory observation, students were comfortable with the software because they were able to carry out tasks or assignments given to them. This shows that ArcView-GIS provide a user-friendly interface for learners to engage with GIS knowledge.

3. Does ArcView-GIS meet its aim in terms of its functions?

Deducing from the aims of the software and the results in test, interviews, questionnaires and participant observation (Chapter 4), the software meet its aim in terms of it functions. Results from skills test shows that Post-ArcView-GIS students performed better then Natural Science, Human Science and Pre-ArcView-GIS students. Furthermore the questionnaire reveals that students agreed that ArcView-GIS improved them in skills, knowledge and attitudes. The interviews also gave the positive response about ArcView-GIS software, expects also agreed that students cognitively developed after using ArcView-GIS software. In the literature review this is also supported, ArcView-GIS provide students with the knowledge and skills necessary to, develop practical skills using commercial software; understand the issues concerning sources, management and analysis of spatial data and design commercial or industrial solutions (ESRI homepage, 2004). Deducing from points above, it means indeed ArcView-GIS do meet its aim in terms of functions i.e. improving student's knowledge, skills and attitudes.

GIS software use tools for the handling, collecting, managing, analysis and modeling of geographic data. GIS strength lies in its ability to combine computer-assisted mapping with statistical analysis of spatial data to perform spatial modeling. GIS can integrate a wide variety of disciplines including agriculture, computing, economics, and geography. It can assist in the analysis of many social and scientific problems on a global, national and local level. GIS is used as the integration of spatial data acquired at different scales and times, and in different formats into a single database. It can be used for the

enhancement of measurement, mapping, monitoring and modeling of spatial phenomena. Using GIS improves our understanding of the world (ESRI homepage 2004).

ArcView-GIS allows a user to easily create maps, and add your own data to them. Using ArcView-GIS's visualization tools, you can access records from existing databases and display them on maps. It is a powerful, easy-to-use tool that enables you to visualise, explore, query and analyse geographic data spatially. The applications of ArcView-GIS allows for scaffolding that enables learners to do more advanced activities and to engage in more advanced thinking and problem solving than they could without such help.

ArcView-GIS is one of these emerging educational technologies that develop contextually rich student learning. Students can construct understandings of the natural world by creating visual patterns in data (Steven, 2004). This kind of work is at the heart of both scientific inquiry and constructivist learning. For student researchers, ArcView-GIS allows for infinite variation in their search of patterns and expands the data that can be included in their search. Using this advanced computer application designed for collecting, storing, manipulating, and displaying data not only expands the data students' look at, but also how they look at it. ArcView-GIS can easily accomplish simple tasks such as mapping location, however it can also handle more complex tasks such as, plotting the density and/or frequency of a particular event. ArcView-GIS will allow more sophisticated tasks, such as finding data points near a particular feature on a map. Perhaps the most complicated and useful tasks a ArcView-GIS can undertake is displaying data that shows change over time or displaying data using a three-dimensional perspective (Steven, 2004).

5.3 Limitations

This study is limited by certain issues which preclude making any generalisations from the findings. These limitations are discussed in turn below.

The study in question had limitations that warrant attention. Firstly there was a lack of control over how respondents completed the questionnaires. As a result it become vulnerable to factors like, for example, the time respondent had to complete the

questionnaire. It is possible that greater accuracy could have been achieved if the questionnaire was completed in the presence of the researcher or his assistants. This was not possible because the area under the survey was geographically scattered and having other commitments.

When conducting the test respondents came from different faculties, different background, for example GIS students mostly consisted students from previously advantage background, and Human Science comprises students from mostly previously disadvantage, also the Natural Science consisted the balanced of previously disadvantage and advantaged students. That means the element of different background from the participants may have an impact on the result of the tests. Anderson, Case and Lam (2001) argue that South African schooling is influenced by socio-economic factors and language proficiency.

Another limitation is that respondents from GIS could not be evaluated prior to involvement to the program because of time and that it was difficult to know which students who were going to do or intending to do GIS as the course prior the evaluation of the arcView-GIS.

5.4 Recommendations

This study aimed to investigate whether ArcView-GIS promotes cognitive development in students studying a GIS course at the University of KwaZulu-Natal. The major findings of the research were that GIS students have gained knowledge, skills and applied competencies in a number of fields related to the design of maps, analysing, development and use of digital technologies in research. More specifically they have gained advanced skills and insights into the use of arcView-GIS to support research activities including project management skills, research skills, presentation skills and reflection skills. I therefore encourage the use of the software at the university so that there are common applications.

I recommend that more research should be done in this topic because there is no other research in this topic. Researches in the field of computer-assisted education focus mainly on the use of computer-assisted education at tertiary institutions and not in South African high schools. The methods of collecting data for this project had a number of limitations. The questionnaire and interviews had some limitations and some research questions could not be answered due to the lack of appropriate information. Email correspondence with the director of Information Technology of Education (ITEd) was utilized as an additional data collection instrument during the writing of this dissertation. These emails were sent to obtain supplementary information.

I recommend that the researcher should start by investigating the participants before they even start using the software itself and after the software and see if there is improvement. Future research should initially be restricted to a number of faculties in a predefined area. For instance, research can be done at selected faculties in the greater University of KwaZulu-Natal area. If the research is viable, it can be extended to more broadly defined area, which could include a larger number of faculties such as management faculties.

I also recommend that the course must also be done in high schools in South Africa as it is the case in overseas e.g. in Canada.

5.5 Conclusion

The literature review has been found to be adequate for this project. Recommendations for further research have been made based on previous researches.

It is my belief that the research question has been answered in this thesis to such an extent that more students and educators will have an interest in using arcView-GIS or even do the course in GIS. It is also my belief that the research has been ethnically done and the findings are valid and authentic, reliable and credible.

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Appendix 1. Modified Questionnaire for Human Computer Interaction and Cognitive Development Questionnaire

Please circle the numbers that most appropriately reflect your impressions about using ArcView-GIS

PART 1: Human Computer Interaction

Statement	Disagree			Agree	
1. The software always keep users informed about what is going on, through appropriate feedback within reasonable time.	1	2	3	4	5
2. The language used to label screen information (i.e. user interface) was simple and familiar to the user.	1	2	3	4	5
3. The software allows users to easily correct, or recover from, mistakes or errors.	1	2	3	4	5
4. The same, or similar, steps are used to performed related tasks.	1	2	3	4	5
5. It is easy to make mistakes.	1	2	3	4	5
6. Objects, actions and options were always visible.	1	2	3	4	5
7. There were keyboard shortcuts in the arcView-GIS software	1	2	3	4	5
8. The software did not offer more than is required for the user to perform a task, but it is aesthetically pleasing.	1	2	3	4	5
9. Error messages are useful.	1	2	3	4	5
10. It is easy to find, or search for, information provided by ArcView-GIS	1	2	3	4	5

PART 2: COGNITIVE DEVELOPMENT

Statement	Disagree			Agree	
1. ArcView-GIS helped me to develop better decisions making skills which helped me solve GIS problems more quickly.	1	2	3	4	5
2. ArcView-GIS helped me to develop my data presenting skills	1	2	3	4	5
3. Working with ArcView-GIS allowed me to create, query, map, and analyze spatial data easily.	1	2	3	4	5
4. Working with ArcView-GIS improved my visualization and spatial reasoning skills.	1	2	3	4	5
5. Working with ArcView-GIS improved my analytical	1	2	3	4	5

	solving problem skills.					
6.	ArcView-GIS helped me to gain a deeper understanding of geographical and environmental knowledge.	1	2	3	4	5
7.	ArcView-GIS helped me understand spatial data and the relationships between spatial, location and/or geographical information.	1	2	3	4	5
8.	ArcView-GIS helped me understand that spatial data can be represented as polygons, lines and points (raster and vector data).	1	2	3	4	5
9.	ArcView-GIS helped me understand that the earth is neither flat nor round, but is curved	1	2	3	4	5
10.	ArcView-GIS helped me to better understand concepts presented in the GIS course.	1	2	3	4	5
11.	Experience with ArcView-GIS has changed the way I perceived and interpreted maps.	1	2	3	4	5
12.	Experience with ArcView-GIS made me change the way I viewed social and environmental issues.	1	2	3	4	5
13.	Using ArcView-GIS was a valuable learning experience.	1	2	3	4	5

13. What is the best feature of the ArcView-GIS software?

14. How would you improve the ArcView-GIS software?

15. Please write any other comments about this GIS course on the back of this sheet.

Appendic 2. Modified Evaluation Interview Protocol

Name: _____ Interviewer: _____ Date: _____

1. What is your specialty?
2. How many years and months in present position? _____ years _____ months
3. Please describe your use of the ArcView since the "arcView Training" in GIS course.
4. Please describe your first reactions to "arcView" in GIS course.
5. Please describe your present opinions of "arcView" GIS course.
6. Do you need additional training to use "arcView?"
7. To what degree did you accomplish the performance objectives established for the "arcView" in GIS course?
8. Would you tell other learners to take the "arcView" GIS course?
9. What kinds of successes have you experienced with the "arcView" since the training?
10. What kinds of problems have you experienced with the "arcView" since the training?
11. Please describe the areas in which you feel most competent concerning use of the "arcView."
12. Please describe the areas in which you feel least competent concerning use of the "arcView."
13. Did students change in knowledge, skills and attitudes after finishing the GIS course?
14. Does ArcView-GIS meet its aim in terms of its functions?

Appendic 3. Skills test

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 cross 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
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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.

Sample Answer

(A) (B) (C) (D)

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

Female		Male	
--------	--	------	--

 sex

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	
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11. What is the highest level of education reached by members of your family?

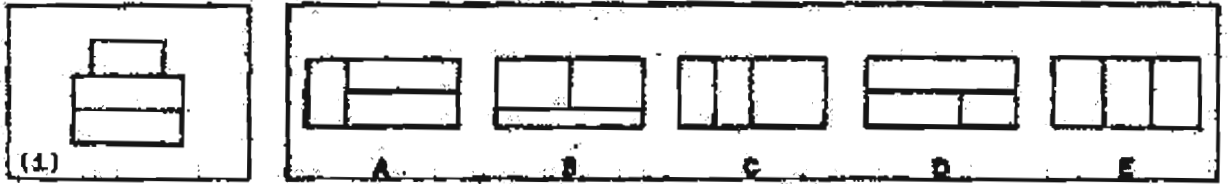
<i>Mother/Guardian</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Father/Guardian</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Sibling 1</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Sibling 2</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Sibling 3</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Sibling 4</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	
<i>Sibling 5</i>	Below Std 8/ grade 10		Std 10 / Grade 12		Technikon		University	

Which of the following items do you have at home?

<i>Electricity</i>	
<i>Running water</i>	
<i>Car</i>	
<i>Fridge</i>	
<i>Microwave</i>	
<i>TV</i>	
<i>Cell phone</i>	
<i>Phone Telkom</i>	
<i>Computer</i>	
<i>Laptop</i>	
<i>Internet connection</i>	

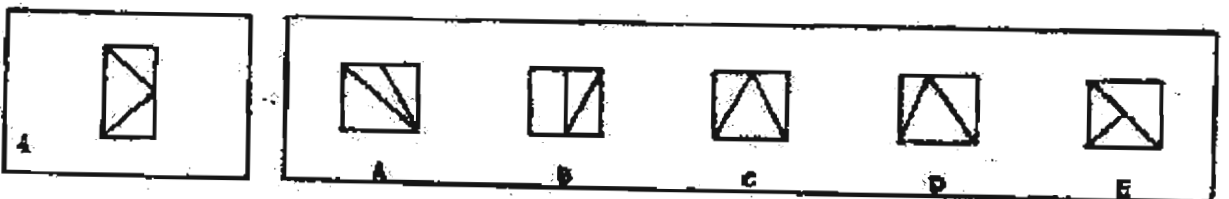
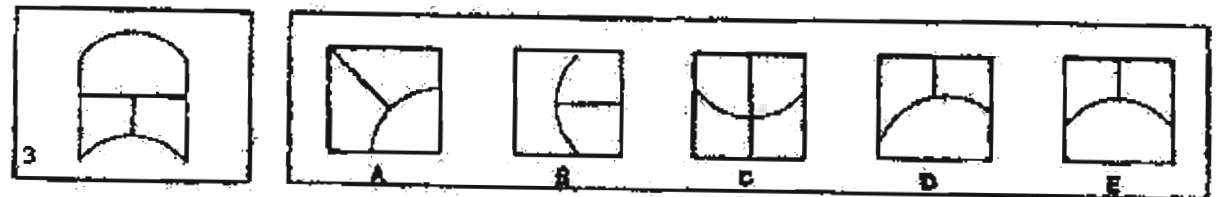
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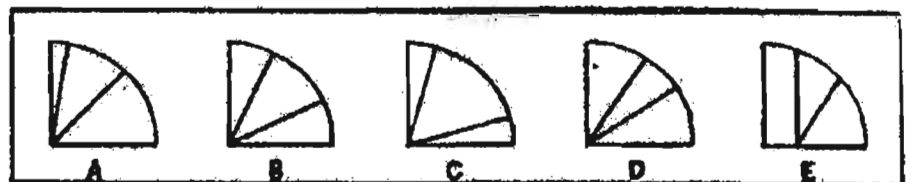
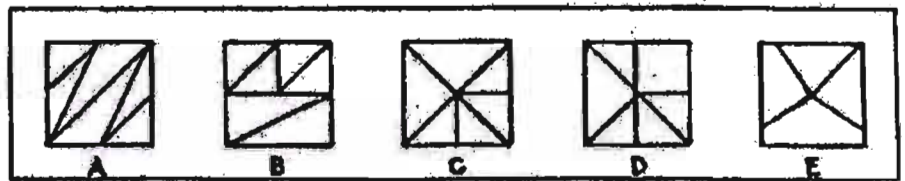
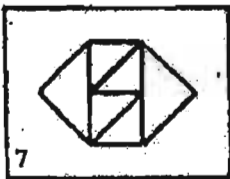
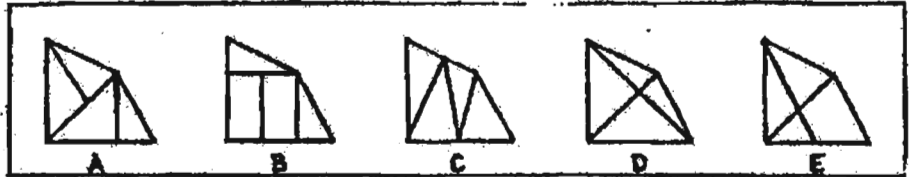
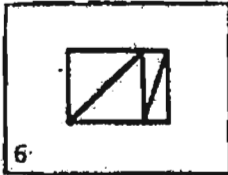
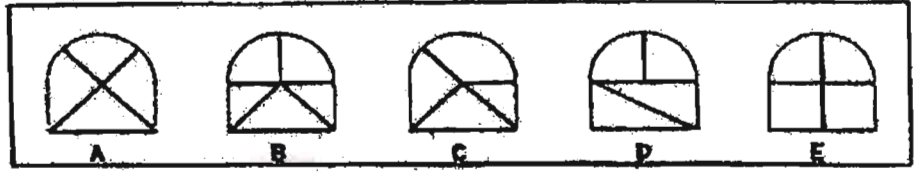
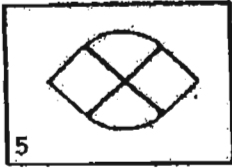
These are exercises in finding rearranged figures. Find the lettered figure which is made up of the same pieces as the numbered figure. Below is an example:



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:



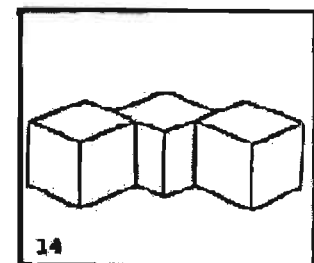
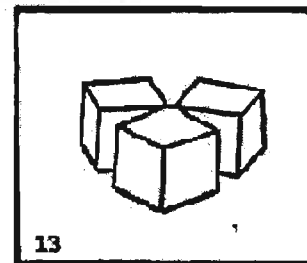
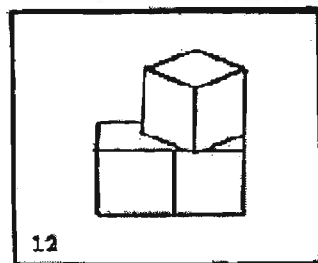
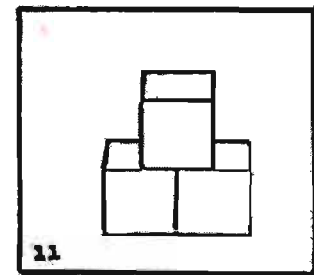
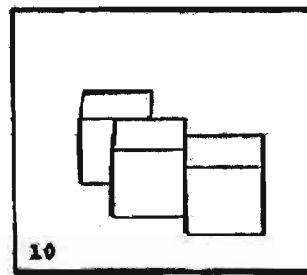
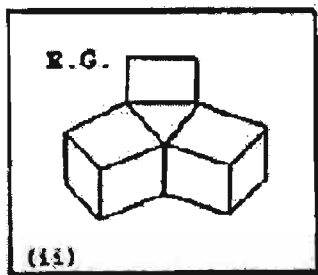
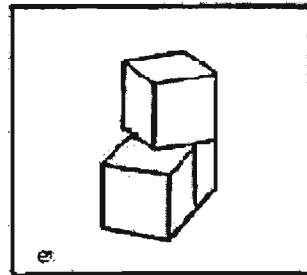
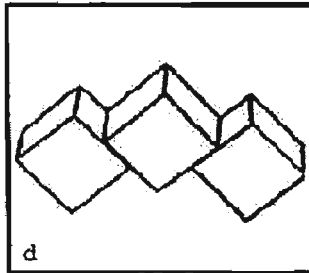
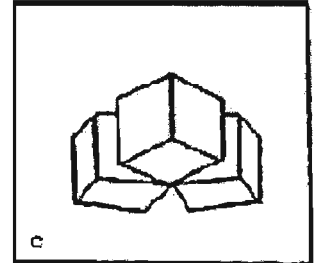
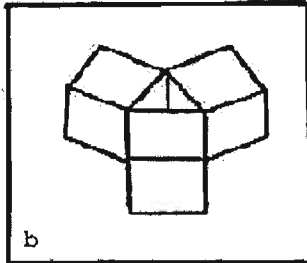
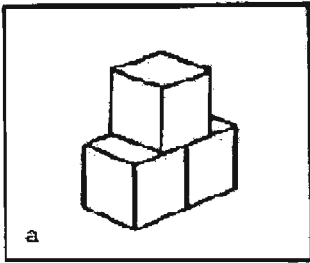


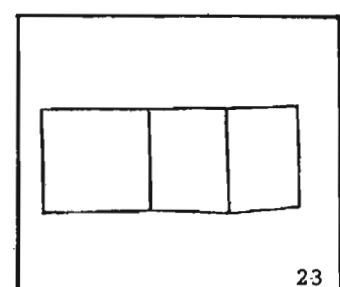
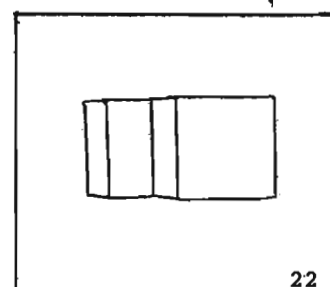
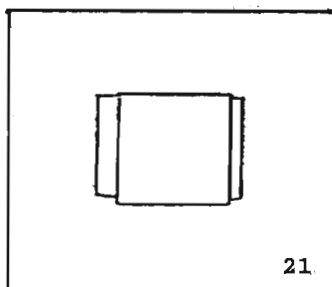
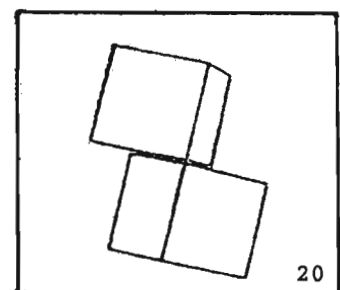
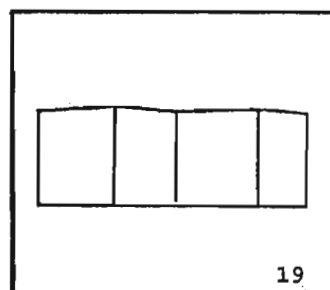
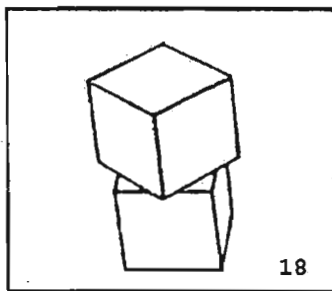
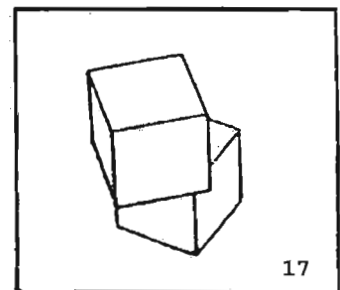
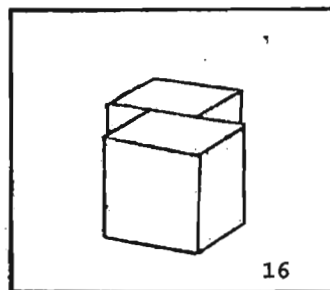
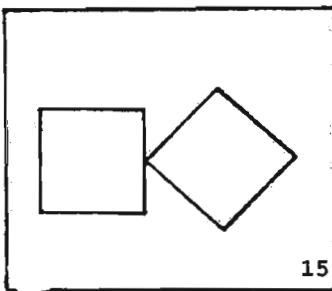
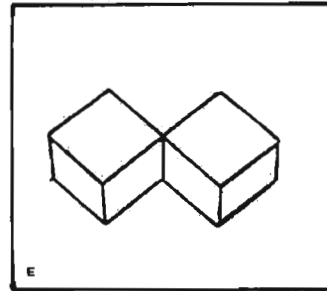
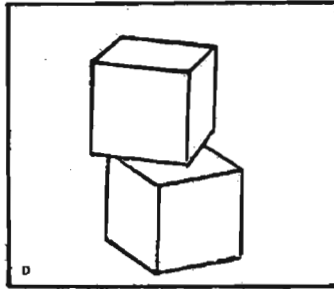
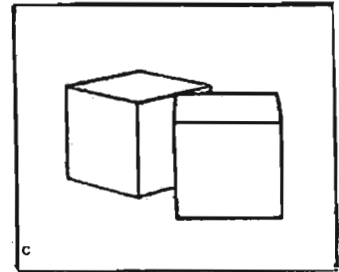
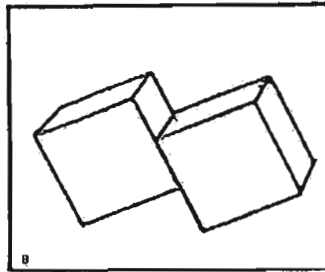
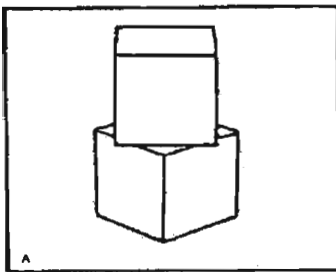
Part 3

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





Part 4

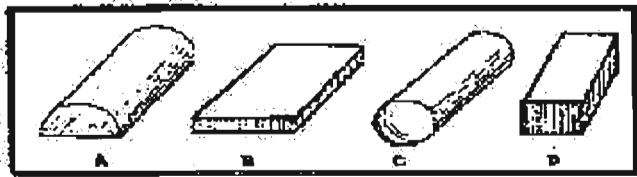
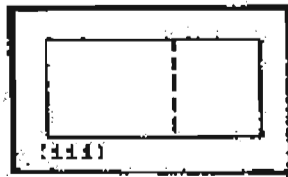
These are exercises in finding objects made from pieces of metal or cardboard. In the example below, on the left is a drawing which represents a flat piece of metal. The dotted lines indicate where the metal is to be bent. On the right are drawings of four objects. In each exercise, only one object can 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)

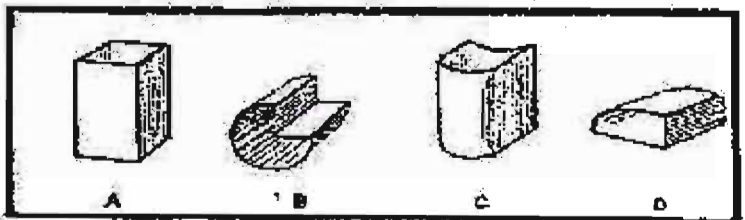
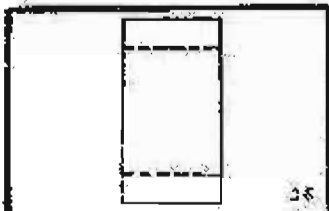
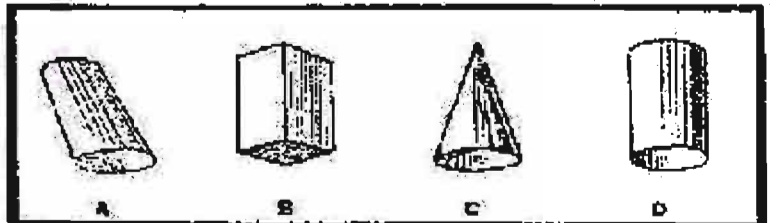
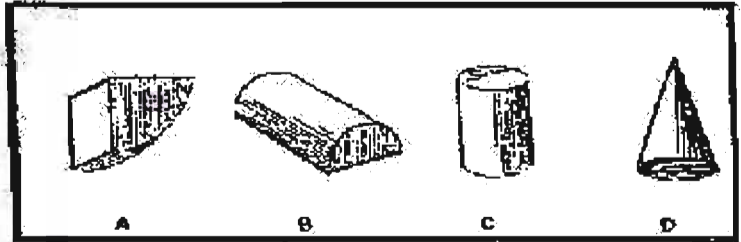
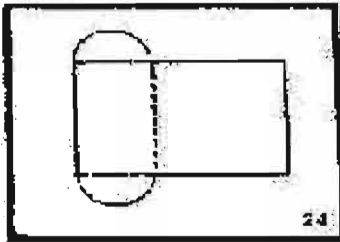
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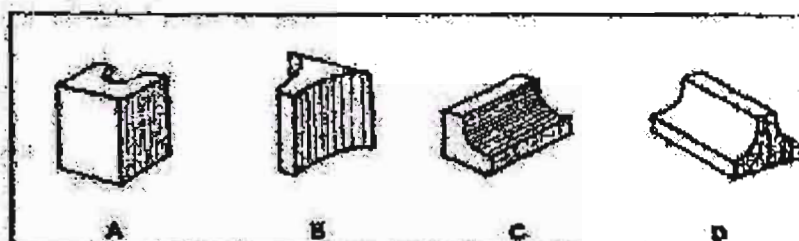
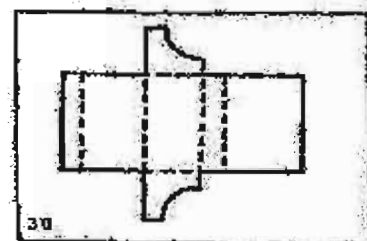
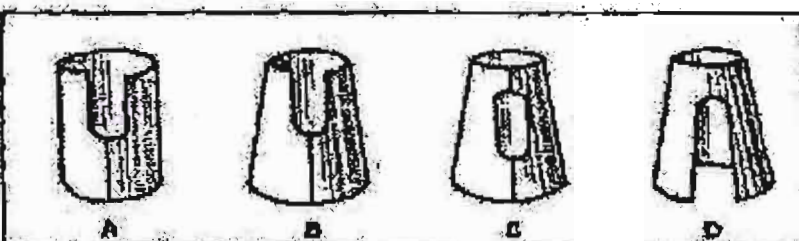
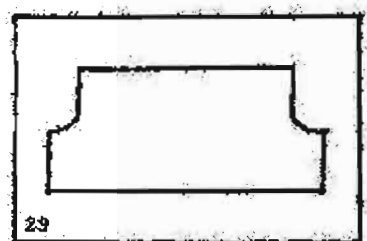
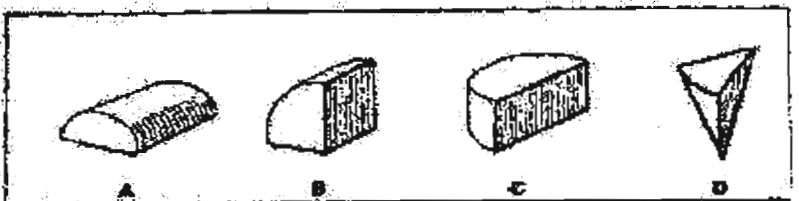
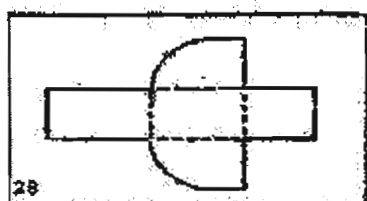
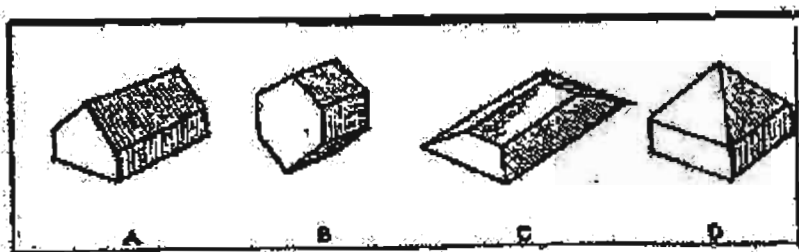
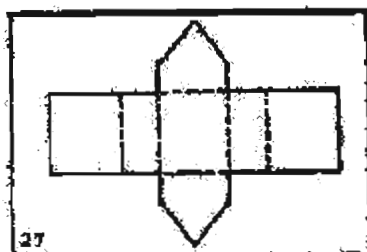
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,



Do the following:





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) $4\frac{1}{2}$ (c) 5 (d) $\frac{1}{2}$ (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

☐ A ☒ B ☐ C ☐ D

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

☐ A ☐ B ☐ C ☒ D

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
-

Written Expression

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.

☐ ☒ ☐ ☐

A **B** **C** **D**

The sentence should read, "Serving several terms in Congress, Shirley Chisholm became an important United States politician." Therefore, you should choose answer B.

D

of foods.

68. The gopher digs with the strong claws of its two front foot and with its overhanging front teeth.

A

B

C

D

69. The cosmonaut and the world's second space tourist, Mark Shuttleworth, displayed excitement about

A

B

C

them plans for genetic experiments in space.

D

70. As two nuclei move closer together, their mutual electrostatic potential energy becomes more large

A

B

C

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

☐ A ☐ B ☒ C ☐ D

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

(A) (B) (C) ●

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