A KIRKPATRICK EVALUATION OF COMPUTER-INTEGRATED LEARNING SUPPORT MATERIAL FOR TECHNOLOGY EDUCATION

A dissertation of limited scope by
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submitted as partial fulfilment for the requirements of the degree
MEd (CIE)

in the
Department of Curriculum Studies
of the
Faculty of Education
at the
University of Pretoria

Supervisor
Prof A.S. Blignaut

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I wish to thank my God for strength, drive and ability.

Abstract

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Degree: MEd (CIE)
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The aim of this research is to establish which aspects influence students' successful learning of design skills through contextually integrated learning support material for the design and technology education programme at the University of Pretoria. The purpose of the research is threefold:

- The first aim is to investigate the extent to which the electronic tutorial, *Design in Action*[1] (hereafter referred to as "the tutorial") contributes to students' (novice designers) design theory in a technological context i.e. to indicate whether the level of sophistication of the exemplary graphics and explanatory text is suited to the context.
- The second aim is to establish the levels of learning achieved by learners as a result of the intervention using *Design in Action* in order to indicate the adequacy of the learning support material in achieving the learning outcomes of the unit.
- The third aim is to establish possible improvements for the tutorial to increase its effectiveness in terms of curriculum, media & technology, learning & instruction and teacher education & didactics (Van den Akker, 1999).

The findings of this preliminary study will be used in broader studies focused on the design and development of contextually integrated learning support material for design and technology education students.

This research is a qualitative case study, including the evaluation of levels of learning of first year pre-service design and technology students, conducted in the interpretative paradigm, within the theoretical frame of socially responsible research (Reeves, 2000).
The evaluation of the levels of learning was based on a model designed by Kirkpatrick (Kirkpatrick, 1994). The model delineates four levels of instruction (training) outcomes: reaction, learning, behaviour, and results.

[1] *Design in Action* is an electronic self-study guide designed as contextually integrated learning support material for first year technology education students at the University of Pretoria.

Keywords

Aesthetics	One of the design aspects to be considered in the design of products, which is also considered as the universal visual language providing the necessary rules for synthesizing the basic carriers of meaning (Parr, 2004).
Design	The concept "design" was taken from the definition of the "act of designing" as part of the design process as prescribed for grade 9 in the RNCS (Department of Education, 2002, p.37)
Design aspects	It is generally accepted in design studies that the concept "design aspects" refers to the functionality, aesthetics, ergonomics and value of man-made products (Department of Education, 2002; Garratt, 1996; Press & Cooper, 2002).
Design elements	"Elements" refers to aesthetic design elements, e.g. shape, line, texture, colour/tonal value, illusion of movement (Lauer, 1985).
Design principles	"Principles" refers to aesthetic design principles, e.g. unity, emphasis, balance, proportion, rhythm, illusion of space (Lauer, 1985).
Design process	"Process" refers to the model prescribed by the RNCS (Department of Education, 2002) of which the steps are: investigating, designing, making, evaluating and communicating.
Drawing	The act of "drawing" is an important part of the "designing" and "communicating" steps of the design process (Department of Education, 2002) and seen as a tool to develop "designerly thought" in design and technology students (Garner, 1993).
Levels of learning	"Levels" refers to Kirkpatrick's (1994) model of four levels of learning that should be evaluated in order to establish the effectiveness of instruction, namely reaction, learning, transfer/behaviour and results.
Technology education	The learning area "Technology Education" is a relatively new one and was incorporated in the band of general education of schools in 1997, when it also became part of teacher training at the University of Pretoria.
Utility judgements	Students' individual and subjective perceptions of the usefulness of instruction and instructional material (Alliger, *et al*, 1997).

Abbreviations

CAL	Computer assisted learning
CIL	Computer integrated learning
DoE	Department of Education
ICT	Information and communications technologies
OBE	Outcomes based education
RNCS	Revised National Curriculum Statement
WWW	World Wide Web

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1.1 Conceptualising the study

The aim of this research is to establish the aspects that influence students' successful learning of design skills through contextually integrated learning support material for the design and technology education programme at the University of Pretoria. The purpose of the research is threefold:

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1.2 Deriving the research topic from preliminary reading

According to Custer (1995), the incorporation of technology education into general education is an acknowledgement of the profound influence technology has on all aspects of human life, and there is a critical need for all individuals to develop at least minimal levels of understanding with regard to the design aspects of technology as well as cultivating basic design skills.

The survey of the literature conducted by researchers in the field of technology education revealed that the way learners gain knowledge and/or understanding of design and technology is not yet fully understood (Atkinson, 1998). According to Stein (Stein *et al.*, 2001), research indicates that the design process is a fundamental tool which contributes to learners' understanding of the role of design in technology. In addition, the way in which learners gain technological thinking skills, should be seen against the "unique character" of technology

[1] *Design in Action* is an electronic self-study guide designed as contextually integrated learning support material for first year technology education students at the University of Pretoria.

education, as defined by the South African Department of Education (DoE) (Department of Education, 2002):

- solving problems in creative ways;
- using authentic contexts that are rooted in real situations outside the classroom;
- combining thinking and doing in a way that links abstract concepts to concrete understanding;
- executing practical projects using a variety of technological skills (design processes);
- providing for a variety of learning styles; and
- using and engaging with knowledge in a purposeful way.

The DoE further explicitly indicates in the *Revised National Curriculum Statement* (RNCS) that the mastery of the design process is the backbone of the learning area (DoE, 2002). Learners have to actively engage in the design process. The literature indicates that the design process has been represented in many different ways, mainly making use of linear or iterative models (Fordyce, 1992; Schön, 1987; Stein *et al.*, 2001; Travers, 1993). Figure 1.1 is a diagram of the algorithm or model of the design process as prescribed by the DoE (Department of Education, 2002).

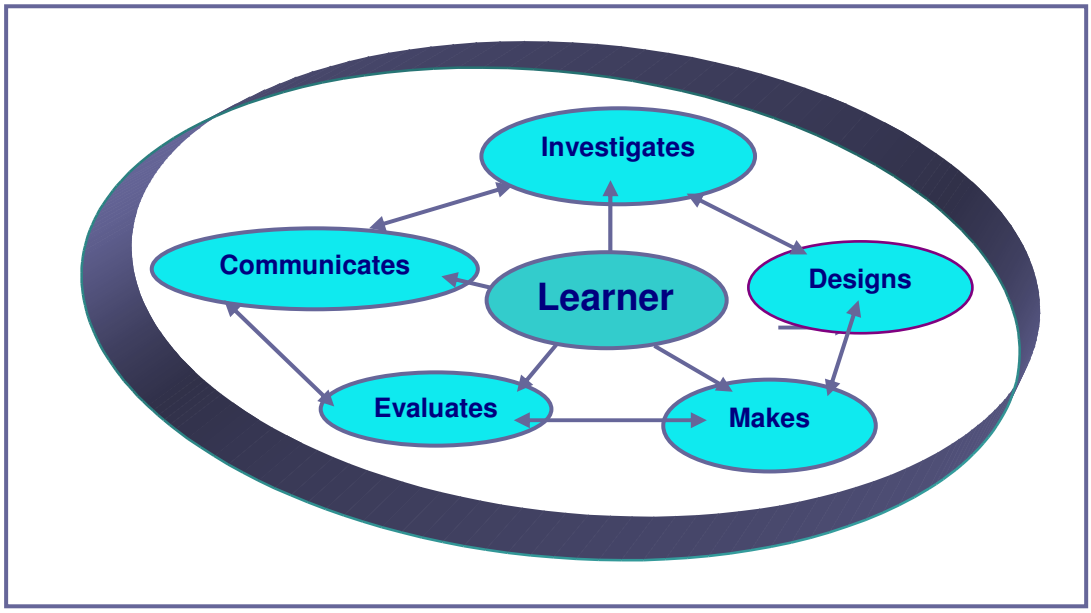

Figure 1.1 A model of the design process as prescribed by the *Revised National Curriculum Statement Grades R-9* (DoE, 2002)

From figure 1.1 it is apparent that the DoE regards the design process as an iterative process in which the learner is central to the implementation of the different iterative steps in the process.

Several facets outside of the *RNCS* (Department of Education, 2002) influenced the design of learning support material for the design skills in the design process. However, for the purpose of this study the focus will be on the domain of aesthetics in design studies.

One of the key concepts that plays a deciding role in the design and implementation of the curriculum of the design and technology education programme in the Faculty of Education at the University of Pretoria, is the "quality" of a product as realised in authentic real life design and technology contexts. Scientific, technological, economic, political, judicial and aesthetic factors play a role in technological innovations. Press and Cooper (2002) identify four main aspects to be considered when striving for quality product design:

- function;
- aesthetics;
- ergonomics and
- value.

The focus of this study is on the

- constructs of aesthetic aspects (design principles, elements and techniques), determining the quality of a design;
- the content knowledge required to critically analyse existing designs and
- drawing skills to visualise the understanding of design in students' own designs (Anderson, 1998; Tversky, 1999).

The term "aesthetics" refers to the formal design theory, namely, that principles are rules that govern the arrangement of elements by applying techniques (Lauer, 1985; Wong, 1993) as was illustrated and explained in learning support material, e.g. the tutorial interventions and class discussions. Principles, elements and techniques are the domain specific constructs forming the basis of this research. The design principles are unity, balance, emphasis, scale/proportion, illusion of space and rhythm. Elements are line, shape/volume, colour/tonal value and texture. Techniques involve numerous arrangements in space, e.g. groups, orders and distances achieved through, amongst others, repetition, addition, omission and distortion (Tversky, 1999). Learning aesthetic design theory is considered as domain specific constructs that can be divided into separate segments, cognitively operating as a visual vocabulary for the designer (Tversky, 1999) in a universal visual language (Anderson, 1998). This visual language is used to make

drawings understandable to viewers and enables the designer to reveal ideas and intentions. In addition, drawings are clues to mental conceptualisations of specific domains (Tversky, 1999).

The way in which the module, JOT120, was designed to facilitate students' mental conceptualisation of the constructs of design, principles, elements and techniques will subsequently be discussed.

1.3 The module

The design module, coded JOT120, is a semester course. It is presented during the second semester of the group's first year of study in design and technology. It follows on two modules: JOT151, Conceptual framework of technology and JOT152, The design process, including creative and critical thinking skills, perceptual development and visualisation (making understanding of concepts visual) techniques. When students start with JOT120, it is assumed that they have a conceptual understanding of the technological processes involved when seeking practical solutions to needs and problems experienced by humans and that they understand the importance of the aesthetic aspect of product design in the context of a market driven approach[2] (Parr, 2004) towards product design.

1.3.1 The approach

The implementation of the module was approached from a constructivist point of view. It was learner centred and project-driven. Two main aspects drove the implementation of the module in the constructivist paradigm:

- scaffolding: through learning support material, structured lectures, class discussions, class activities – visual analysis, drawing skills; and
- problem solving through implementation of the following steps in the design process: identifying the problem, investigating the need, researching content knowledge available to support understanding of the problem and suggesting possible solutions, communicating possible solutions through exploratory and representational drawings.

Independent learning and collaborative learning based on prior knowledge were expected of the participants. The problem-based approach to the module afforded multiple opportunities to realise the unique concepts and characteristics of technology education in the following way:

[2] Market driven approach: aesthetic choices are quite often based on and motivated by market surveys, studies of competing products, and studies of defined target user groups, in order to make the product fit a favourable niche among other products (Parr, 2004).

- solutions are open-ended;
- problems have more than one possible solution and there is always more than one way to get to a practical solution;
- students are assessed by how they get to the solution, as well as the quality of the solution itself;
- the lecturer's role is that of facilitator of learning, rather than that of transmitter of information (Rubin, n.d.).

In order to help the students with the necessary skills to generate ideas, visualise solutions and communicate their ideas, they were simultaneously exposed to undirected and directed tutorials, exercises and contextually integrated learning support material forming the necessary scaffolding for the problem-based projects. This took place through formal classes, computer assisted tutorials and home assignments, with formal drawing and analysing exercises as a progressive series of project-based design interactions.

The lecturer provided a variety of learning support strategies, in order to scaffold participants' search for information and knowledge on the four design aspects, e.g. through investigating and design tasks. One of the learning support materials that were prescribed as a compulsory research source was the tutorial, *Design in Action,* which dealt with the aesthetic aspect.

1.3.2 Aim and focus of the module

The aim of the module is to equip students with the required knowledge and skills to achieve the variety of technological skills required by the *RNCS* (Department of Education, 2002) implied by the design process (figure 1.1). This entailed the following:

- introducing learning to design principles and design elements;
- enabling students to master the basic drawing and representation skills in order to generate and develop ideas in a graphic manner; and
- enabling students to represent and communicate them in a visual manner and applying design principles in their product designs.

It is for this reason that I designed a module to provide students with the opportunity to learn by investigating, analysing, generating ideas, designing solutions and revealing intentions visually. For the purpose of focusing on the structured order in which the tutorial, *Design in Action*, was implemented, it should be viewed within the context of which the module formed part.

1.3.3 The structure of the module

The module was structured to start with an reiteration of the concept of the design process, progressing onto a series of semi-structured interactions within the module, including lectures, during which the lecturer presented key ideas, about, for example, the compilation of a visual diary according to a selection of design paradigms, colour theory, free-hand sketching, colour rendering and three dimensional modelling. Drawing became the tool for generating new ideas, testing, recording and communicating them in order to solve problems while considering functionality, aesthetics, ergonomics and values. During tutorials, the lecturer led the learners through various exercises and tests to engage in analytical and critical thinking processes and supported planning sessions for the project. The module concluded with transfer of knowledge through drawing and manufacturing skills being applied in a lampshade project.

The model in figure 1.2 illustrates the structure of the module. It serves both as a simplified way of illustrating some of the aspects involved in this unique learning area and as a teaching aid to guide trainers in the teaching of the interrelationships between the different concepts in technology education.

From the model in figure 1.2 it can by seen that the module has a complex structure with many interrelating facets, domains and skills. While solving a problem embedded in one or more of the knowledge areas in technology education (i.e. structures, processing, mechanisms and systems) the designer/student engages in the different phases of the design process in an iterative manner. They simultaneously consider the four design aspects involved in product design, i.e. function, aesthetics, ergonomics and value (Press & Cooper, 2002) and reveal their ideas and intentions through free-hand drawings.

For the purpose of establishing the role of the tutorial, it should be viewed within the context of how learning took place in the module under discussion. Therefore, evidence of the different activities involving students to reveal their conceptual understanding of the aesthetic domain during the module will be discussed in chapter 4.

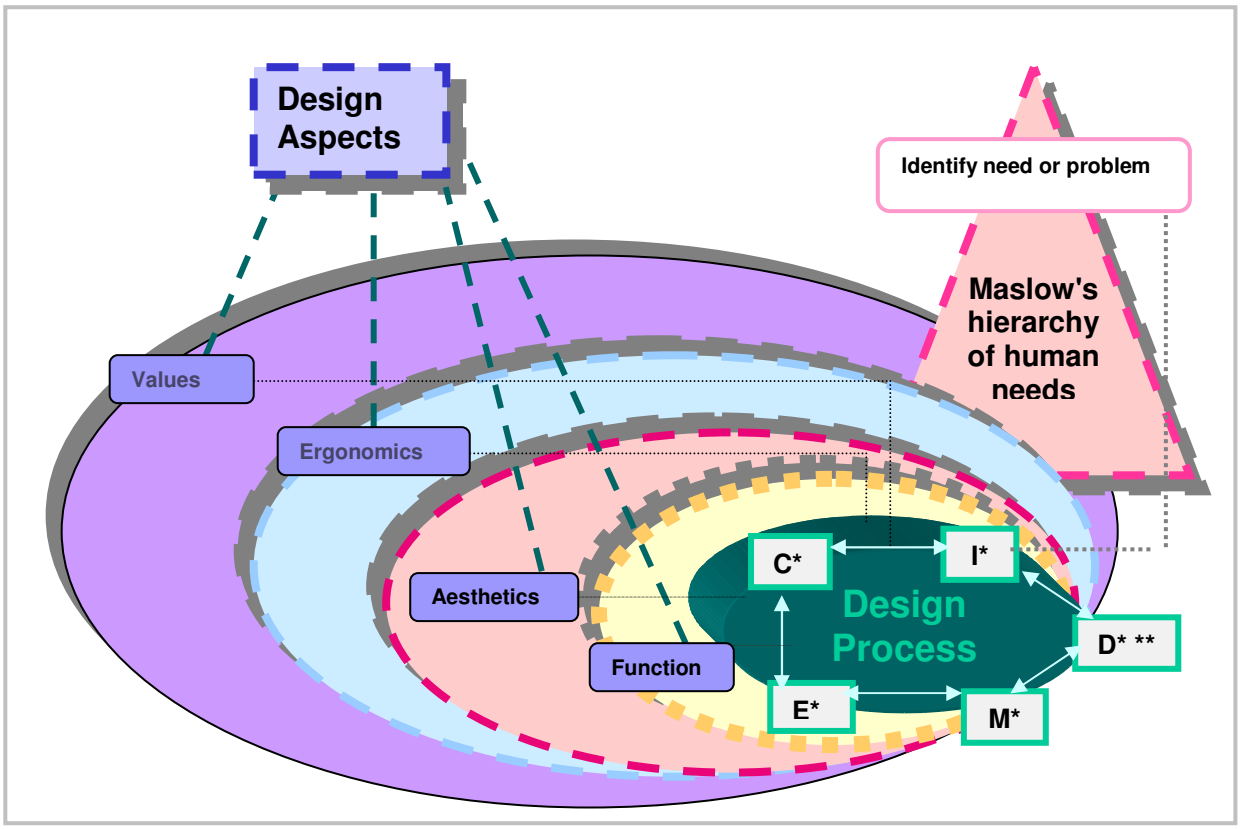

Figure 1.2 Structure for the module JOT 120

* Phases in the design process: I = Investigation; D = Design; M = Make; E = Evaluate; C = Communicate

** Drawing is a core component in the design phase and constitutes 50% of the time allocation to the module

1.3.4 The learning outcomes

By the end of the module JOT120, it was expected that students could:

- identify and solve authentic product design problems by implementing the design process;
- explore more than one possible solution;
- explore more than one way of arriving at a good solution;
- acknowledge the complexity of design problems;
- consider all four design aspects: functionality, aesthetics, ergonomics and value;
- combine thinking and doing by linking abstract concepts to concrete understanding;
- carry out practical projects using a variety of technological skills;
- solve problems through a process of investigating, designing, making, evaluating, communicating which suits different learning styles; and
- use and engage with knowledge in a purposeful way (University of Pretoria, 2003).

By realising the above outcomes for the module, the students will also have reached Learning Outcome 1 of the *Revised National Curriculum Statement Grades R-9 (Schools)* (Department of Education, 2002).

1.3.5 Evaluation and assessment

Assessment of students' knowledge and understanding was summative as well as formative throughout the entire module. It also formed the basis of the evaluation of the role of the tutorial on three of the four levels of learning (figure 1.3), namely level 1: reaction; level 2: learning and level 3: behaviour[3] (Kirkpatrick, 1994). There were two summative assessment opportunities, i.e. one sequential test at the beginning of the project and one examination at the end of the year. I applied formative assessment to the project. A combination of the two types of assessment provided me with a fairly clear indication of students' progress throughout the module. The different intellectual activities and the learning evident in the research data were evaluated according Kirkpatrick's model for evaluating instruction, illustrated in figure 1.3.

Kirkpatrick's (1994) model within the theoretical frame of the research methodology will be discussed in the literature survey in chapter 2. The implementation of this model will be discussed in chapter 3 and the findings of the evaluation will be reported on in chapter 4. Subsequently the conceptualisation, development and implementation of the tutorial will be discussed.

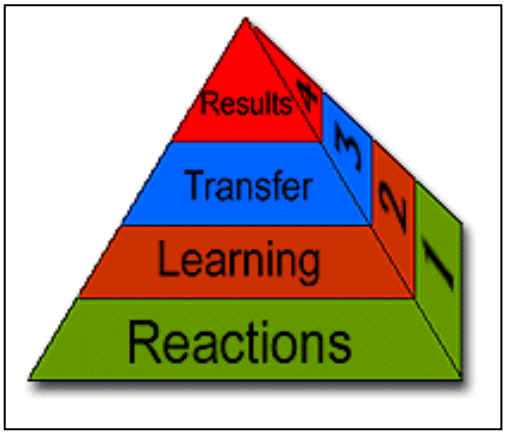

Figure 1.3 Kirkpatrick's model of the levels of learning (Winfrey, 2002)

[3] Level 4: "results" were not relevant to this study. According to Winfrey "results" are seldom relevant in educational contexts (Winfrey, 2002).

1.4 The tutorial

The development of educational software for design and technology education in the Faculty of Education at the University of Pretoria is in line with national policies and priorities identified by researchers in the field (Semmelink, 2000). The development of computer-based learning support materials for subject-specific learning programmes that contribute to learners' understanding of the design process as well as technology in general, is in line with the *RNCS* (Department of Education, 2002). Research results from studies by Lundall and Howell (Lundall & Howell, 2000) indicate that there is a need for contextually specific investigations of information and communication technologies (ICT) education in South Africa.

1.4.1 Introduction

The tutorial was designed according to the ADDIE model, which is well known and widely utilised in the instructional design context (Strickland, n.d.) and an acronym for **A**nalysis, **D**esign, **D**evelopment, **I**mplementation and **E**valuation. This model provided me with a structured way of developing, implementing and evaluating the tutorial systematically. It is an iterative instructional design process, where the results of the formative evaluation of each phase may lead the instructional designer back to any previous phase.

1.4.2 Conceptualisation

The tutorial was conceptualised as an electronic slide show consisting of forty-seven slides on Microsoft PowerPoint™, serving as a self-study guide on the basics of aesthetic design theory. The reason why the tutorial was prescribed was threefold:

- in the first instance it provided large groups the opportunity to work simultaneously in groups, and it provided individuals the opportunity to independently do research in visual literacy and aesthetics;
- secondly, it served as an electronic substitute for hardcopy reference that is inaccessible to many students due to their varying socio-economic backgrounds; and
- thirdly, it served as a tutoring aid for the lecturer during interventions.

1.4.3 Analysis

The analysis phase is the foundation for all other phases in the process of instructional design. During this phase I defined the need, identified the source of need and determined possible solutions. During this phase I had to consider the instructional goals of the tutorial, which

informed the design phase. Other factors considered in the analysis phase will subsequently be discussed.

1.4.3.1 The target group

The first step in the analysis was to consider the target group, who were pre-service technology education students in the first year of a four-year degree programme. The group was characterised by diverse gender, language, socio-economic and cultural background, computer skills and exposure to design related activities.

1.4.3.2 Content

The content of the tutorial was an introduction to the domain of the universal visual language of design theory (Anderson, 1998) as a cognitive tool for idea generation, visualisation of solutions, detailing and analysing, to lay some foundations for further development as the programme proceeded through the years. The intention with the intervention of the contextually integrated tutorial was to facilitate learning of design principles, elements and techniques realised through visual analysis and made visible in design drawings (Tversky, 1999).

1.4.3.3 Strategy for instruction

The strategy for instruction selected was that of an unguided tutorial of which the sole purpose was to convey information in a graphic as well as verbal manner. The effectiveness of the information was equally dependent on the selection of specific designs and the simplicity of the language used to explain each design principle demonstrated in the example. The first exposure to the tutorial was unguided. Thereafter, the lecturer in a variety of ways used it during class discussions, self and peer evaluation of ideas and designs during which times students were exposed to guided interpretations of the tutorial as well as the application of the constructs to the students' designs.

1.4.3.4 Delivery options

Available options for the delivery of the learning support material were the World Wide Web (WWW), internal server, or CD Rom. Platforms to be used for the design of the instructional material were Authorware™, Dreamweaver™, Microsoft FrontPage™ or Microsoft PowerPoint™.

1.4.3.5 Timeline for completion of the tutorial

The designer were allowed four weeks in which to complete the tutorial on a part-time basis. Two weeks were set aside for compiling the database and selecting internet links, one week for adding the explanatory text and one week for creating hyperlinks, programming and testing.

1.4.3.6 Constraints

Aspects constraining the design of the tutorial were identified as:

- development time;
- financial constraints;
- computer resources for design;
- lack of time for training students;
- characteristics of the group viz. size, diversity, Internet access.

Time constraints for the development of the software severely hampered its design. The lack of available staff trained to develop a fully interactive program in one of the more sophisticated platforms, such as Microsoft Authorware™ or Dreamweaver™ within the time frame also influenced the selection of a platform. Financial constraints prevented the designers to contract private programmers for development. Together with this constraint, the lack of available training time for students, the size of the group and their diverse computer literacy skills, the extent of interactivity of the program was greatly influenced.

Students' computer competency ranged from those learners from deep rural areas, without any prior experience of any computers, to those students from high socio-economic backgrounds with very sophisticated computer skills. This factor would severely hamper training of those students with no prior computer experience to optimally use a fully interactive program. Only one lecturer would have to tend to the individual needs of 22 students in the computer laboratory.

1.4.4 Design

The design phase involved using the outputs form the analysis phase to plan a strategy for developing the tutorial. During this phase I outlined how one could reach the instructional goals determined and how one could expand the instructional foundation. The factors considered during the design phase will subsequently be discussed.

1.4.4.1 The platform

The tutorial was created in Microsoft PowerPoint™ because it was under construction and this platform posed the following advantages for the development process, namely:

- it was easy to design a tutorial within limited time;
- it did not require much training for inexperienced students to learn how to use;
- it allowed for good quality reproduction of images;
- it allowed for easy application of design principles advocated through its content;
- it would be easy to improve on;
- it allowed for relative easy change and improvement; and
- it allowed for development into a multi-directional branching system (Montgomery & Wiley, 2004).

1.4.4.2 Access

Students could access the tutorial through the university's academic management system, WebCT, which could only be entered through the WWW. The program uses 6,208KB space and on average, it takes five minutes to download from the Internet. The average time for students to work through the entire program in one session was estimated at two hours.

1.4.4.3 Programming

The tutorial has a linear structure with one branch linking to relevant hyperlinks on the WWW. This type of structure is considered the simplest type for tutorials (Alessi & Trollip, 2001). The program consists of 55 full colour slides, each with examples of authentic products and text explaining design principles applied in order to achieve aesthetically pleasing designs.

The content was divided into three parts:

- part one: design principles:
  - unity,
  - emphasis,
  - balance,
  - scale,
  - illusion of space, and
  - rhythm;
- part two: design elements:
  - line,

  - shape,
  - texture,
  - colour/value, and
  - illusion of movement;
- part three: design problems (exercises).

The tutorial has limited user control. Users only have the options of moving forward and backward one slide at a time. Figure 1.4 illustrates a model of its linear structure and sequence, with simple branching to Internet links.

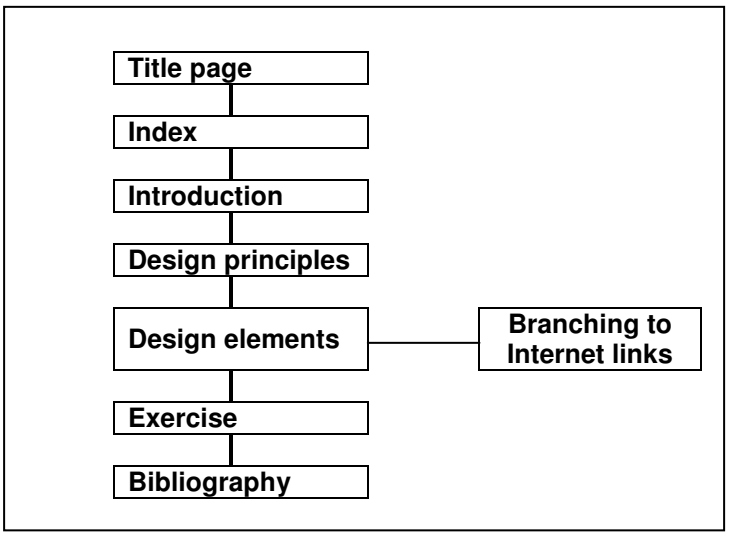

Figure 1.4 Structure and sequence of the tutorial *Design in Action*

The design of the software was determined by:

- the limited computer skills of some of the class members;
- the limited time for the development of a complex interactive program;
- the limited time for specialised training of students to master complex interactivity;
- the possibility to apply all the aesthetic design principles in a concrete way in order to support the content; and
- the ease through which improvements could be brought about.

1.4.4.4 Storyboarding

A storyboard was created to facilitate the design phase of the process. It consisted of information on the following:

- screen layout;
- organisation and sequence of the program segments;
- interaction;
- user control; and
- use of language.

The contextually integrated tutorial under discussion, *Design in Action*, was designed for individual uses prior to and while students were working on their group projects. To motivate students to study its content individually and independently, it had to appeal to the various aesthetic tastes, cater for individual learning styles, be easy to use, be flexible, have navigational options and control, and be interactive.

1.4.4.5 Screen layout

Design in Action brought across complex and often abstract information regarding design in a simplified manner. Where text was almost minimalist, no animation and no transitions were used and the exemplary graphics would be the focus and dominating element on the screen. Figures 1.5 and 1.6 are examples of the style of presentation in Microsoft PowerPoint™.

Each screen in *Design in Action* was used for one design concept only. In most cases one concept progressed onto more than one screen. The design concept for the screen layout was an uncluttered screen, in order to keep the viewer's focus on the core constructs explained in each slide and not to detract from the exemplary designs.

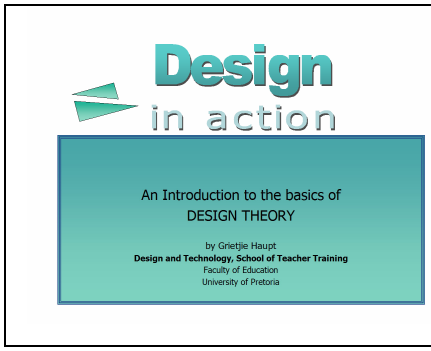

Figure 1.5 Screen shot of the style of presentation in the tutorial

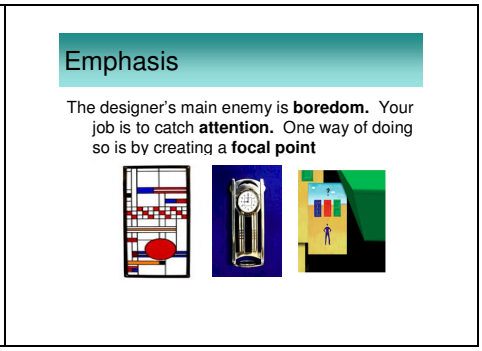

Figure 1.6 Screen shot of the style of presentation in the tutorial

1.4.4.6 Organisation

The tutorial has a sequential structure, branching into a number of hyperlinks to relevant Internet tutorials. At the end of the tutorial a section with exercises, which served as one of the data generating instruments (Addendum 5), was designed. Three types of screens in the tutorial can be distinguished. Firstly, there were definition screens that linked different aspects of the domain (figure 1.7). These screens enhanced the flow of the content and its purpose was to give contextual substantive support, defining the relevant construct, e.g. the different principles (figure 1.7).

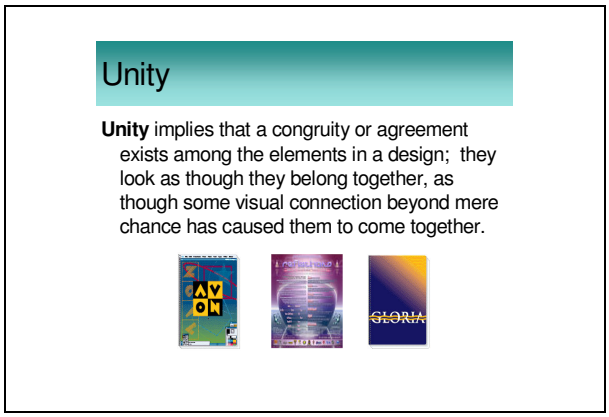

Figure 1.7 Example of the definition screens

Instructional screens provided explanations of the techniques used to arrange design elements (figure 1.8). It provided new content supported with examples and explanations.

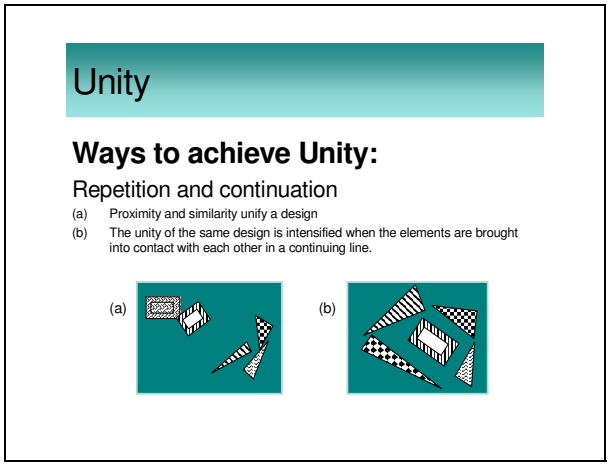

Figure 1.8 Example of an instructional screen

Question screens were used to evaluate students' immediate retention of the content (figure 1.9). These screens required a written reaction from the learner to a question based on the content. I personally gave feedback to these questions in an integrative manner during a lecture.

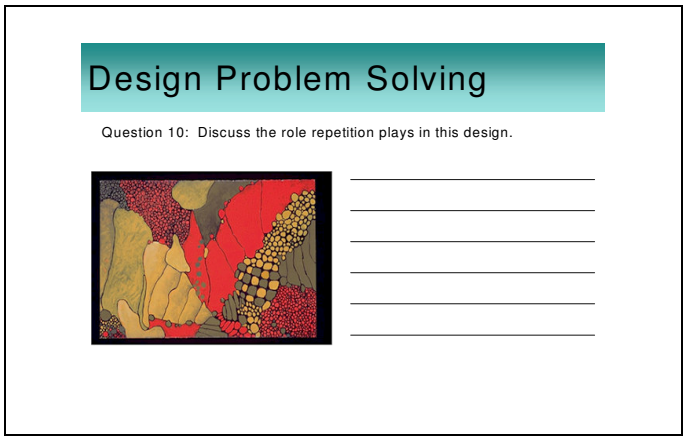

Figure 1.9 Example of a question screen in the exercise

1.4.4.7 User interface

The appearance of the user interface was designed within the theoretical frame of the aesthetic domain, considering design principles, elements and techniques that would support the functionality of the tutorial. My main aim was to design a simple and uncluttered interface. Users could navigate by proceeding in a linear manner only, for instance where an interactive link was created to the Internet (figure 1.4 and figure 1.10). Consistent and uniform colours for the different elements on the screen were used: white for the background; a shaded blue-green for the title band and black for the text. The font style was Arial throughout. Consistent font sizes supported the protocol followed. Size 44 was used for main title headings; size 28 for definitions and size 18 for explanatory text. External links to Internet websites were indicated with hypertext (figure 1.10).

1.4.4.8 User control

The aim of the program was to provide a platform for studying and analysing good quality visual images in a relatively self-paced, asynchronous environment integrated with traditional formal learning conditions. The need for user control would be to have choice of navigating back and forth freely between different sections of the tutorial as well as connecting with the Internet links easily and quickly.

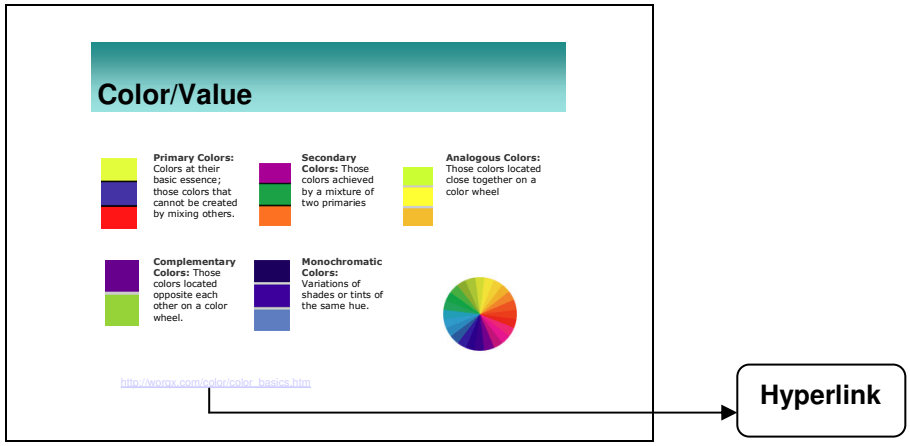

Figure 1.10 Example of a screen with a link to the Internet

1.4.4.9 Collecting needed materials

The content of the software was adapted from a classic design textbook, *Design Basics* by David A. Lauer (Lauer, 1985), which is based on the gestalt psychology of holistic viewing in art making and art related activities (Wong, 1993). Multiple examples of the slides in the software will be discussed in an integrated way when presenting and discussing the data further on. Exemplary designs were collected from various sources, e.g. the Internet, design textbooks and photographs of real scanned objects. Explanatory text consisted of summaries of design textbooks, e.g. by Lauer (1985), Wong (1993) and by Press and Cooper (2002), as well as educational websites on design theory on the Internet.

1.4.5 Development

The development phase augmented both the analysis and design phases. The purpose of this phase was to generate the content of each construct in the tutorial. The design of the tutorial, *Design in Action,* started as a database of exemplary designs that could be presented and discussed with students during formal tutorials and class discussions six weeks prior to the start of the module under discussion. During the time of assembling the database, I decided to extend the examples of designs to include explanatory text in order to familiar students with the design terminology and extend their knowledge base. The development phase consisted of several decisions and actions taken, which will now be discussed.

1.4.5.1 Selecting activities

The learning objectives of the module required students to acquire advanced skills in perspective drawings, observational drawings, working drawings and representational drawings.

They also had to study existing designs of all types of products in terms of function, aesthetics and ergonomics.

The intention with the tutorial was to use it as a source of information through directed and undirected use by students. It was not meant as a tutorial or drill tool. Directed use of the tutorial refer to the lecturer explaining appropriate parts of the content during contact sessions, while undirected use refer to students independently working through the tutorial without any support by the lecturer. The activities designed around the use of the learning support material were restricted to reading the text, studying the examples, drawing relations between text and example through analytical thinking. The exercise at the end of the tutorial consisted of 14 designs requiring students to analyse each in terms of the content of the tutorial (Addendum 5). Students had to write their analyses and interpretations on paper copies of the slides involved while navigating between the slides in the tutorial using it as an open book exercise.

1.4.5.2 Selecting the delivery system

In order to select the most effective delivery system for the instructional material under discussion, the following factors were considered:

- The instructional setting: a computer laboratory on the campus of the University of Pretoria equipped with Pentium 2 (or later) computers and pre-arranged Internet connection was available for one group of 22 students at the first implementation session. For any further use of the tutorial, students could use the laboratory at any time when space was available.
- Media characteristics: the computers were suitable for the tutorial as well as the delivery of the program. The program was developed in Microsoft PowerPoint™ because of its capacity for presenting good quality graphics (Montgomery & Wiley, 2004), the fact that it could bring the design context directly into the classroom and the possibility to branch into links on the WWW.
- As the computer allowed for immediate access to the learning support material, there were no costs involved for the students. The alternative would be to prescribe full colour textbooks and hard copy exercises. However, given the diversity of the students' socio-economic backgrounds, many would not be able to afford expensive imported quality design textbooks. Students, who could afford printing cost, could print the entire tutorial if they wanted to.
- Instructional material: I developed the tutorial in its present format. However, any other interactive programming needed to extend the learning support material into a complex

interactive program, could only be developed by qualified programmers for which a separate budget would be needed.

- Time: for the first implementation session, starting in the first week of the second semester, students had unlimited access to the computers for one week. If additional study time was needed, students could rework the tutorial in their own time and at their own pace as many times as was needed. As the tutorial was fully integrated into the semester module, there were no cut-off dates for revisiting the tutorial.
- Instructors: I developed the tutorial and also acted as the instructor during the first implementation session. Therefore, no additional staff needed to be trained for introducing students to the tutorial.

1.4.5.3 Conducting individual trials

Individual trials of the program were performed on two students at randomly selected times one week before the introduction of the tutorial to the group of 22. Unless they needed help, students were not guided at this time.

1.4.5.4 Revising instruction

The individual trials indicated two types of problems. In the first instance, there seemed to be a problem with the language. This necessitated revising of the explanatory text. Sentences were rephrased and simplified. Font and spelling mistakes were corrected. Secondly, there seemed to be a problem with visual literacy. Some of the examples selected by the lecturer were too advanced or too vague for the students to interpret sufficiently and needed to be replaced.

1.4.5.5 Repeating individual trials

Time constraints did not allow individual trials to be repeated. The use of the tutorial by the entire group during the module was seen as a group trial and considered as part of the formative evaluation of the tutorial.

1.4.5.6 Synthesised into integrated learning programme

Due to the prerequisites of the project in which the students were involved during the module, namely the consideration of the aesthetics as well as the functionality, ergonomics and value of the product they had to design and manufacture, students were required to study the tutorial on their own as part of the investigation phase in the design process. The tutorial was also saved on the hard drive of a notebook installed in the classroom, which was used as standard referencing material during class discussions and evaluation of designs.

1.4.6 Implementation

The implementation phase refers to the actual delivery of the tutorial. The purpose of this phase was to establish the effective and efficient delivery of the tutorial. During this phase I established the level of students' understanding of material through the questionnaire and exercise that will be discussed in Chapter 3. I considered the following aspects for implementing the tutorial:

1.4.6.1 Training of facilitators

Due to the fact that I was the only lecturer involved in the module and responsible for developing the curriculum, learning outcomes, method of delivery and testing procedures, as well as designing the tutorial, no training of tutors or facilitators was necessary.

1.4.6.2 Preparation of the students

During the first group trial I prepared students for accessing the internal site where the software was loaded. I also instructed those unfamiliar with Microsoft PowerPoint™ how to use the software and advised students on good software use strategies. Students were also prepared for answering the questions on hard copy by handing out printouts of the question screens to each one individually.

1.4.6.3 Placing all tools

For the first exposure to the tutorial, students used the on campus computer laboratory where they had access to the internal "Hagar" URL as well as the WWW. Each student had access to a computer in the laboratory. The learning space was, therefore, adequate for the curriculum tools.

1.4.7 Evaluation

The evaluation phase was the focus of this research, which subsequently led to the formulation of the main research question stated in 1.5. The formative evaluation provided me with the following:

- ideas (suggestions and directions) for optimising the quality of the tutorial; and
- generation, articulation and testing of design principles that could either be substantive in nature, referring to characteristics of the intervention, or procedural in nature referring to how it should be developed (Van den Akker, 1999).

During the evaluation phase of the module programme, I concluded that, due to time constraints and the size of the group, the tutorial should be developed into an interactive tool to support students with more evenly spread explanations of all the constructs. The conclusions of the evaluation of the tutorial will be discussed systematically and in detail in chapter 5.

1.5 Articulating the research problem

The following main research question was formulated:

What was the role of the tutorial, *Design in Action* (a computer-aided tool), in Kirkpatrick's three levels of learning in a first year design and technology education programme?

The three research questions and its sub-questions derived from the above main research question will be discussed in detail in chapter 3.

Research relating to the development of relevant contextually integrated learning support material for pre-service design and technology teachers has benefits as it:

- allows for a broader view of the possibilities of developing perceptual skills;
- encourages the culture of research and reflective practice envisaged for technology education in South Africa; and
- adds to the knowledge base of technology education.

1.6 Research design and methodology

This research was the evaluation of an intervention classified as the research methodology of design research. The main aim of outcome evaluation studies is to establish whether the intended (and unintended) outcomes of the tutorial materialised, including short-term and long-term outcomes, using hybrid data with medium control. The purpose of this type of research is to seek a fundamental understanding of the nature of instructional design. I was concerned with the practical use of the research findings. The aim and purpose of this research position it as socially responsible research, as it focuses on understanding "how" instructional technology makes education better (Reeves, 2000). The research methodology will be discussed in detail in chapter 3.

1.7 Outline of the remainder of the dissertation

Chapter 2 contains the literature survey, definitions of key concepts and an integrated discussion of the relevant literature. In chapter 3 the design and methodology followed during the fieldwork and the motivation for choice of the qualitative research method are documented. Chapter 4 includes the results of the investigation, describes the sample profile and indicates the main trends and patterns in the data with reference to the research questions. Chapter 5 concludes the study, thus incorporating a summary of the main findings and a discussion of the salient points. The chapter also includes a discussion of how the results of the research and the conclusions relate to the literature and theory in the domain of aesthetic design theory and the evaluation of instructional material.

2.1 Introduction

The literature surveyed for this study falls in three categories: the first is the category of the levels of learning, the second is the category of design studies and the third is the category of computer-assisted learning (CAL). The study focuses on the way in which first year pre-service technology education teachers' visual analyses of designs as well as their drawings indicate what they have partially learned about aesthetic design constructs through an electronic tutorial. The main research question answered in this study is the following:

What was the role of the tutorial, *Design in Action* (a computer-aided tool), in Kirkpatrick's three levels of learning in a first year design and technology education programme?

The theoretical base set by the literature will be used to answer the research questions in an integrated manner. The categories will now be summarised.

2.1.1 Category 1: Levels of learning

The first category of literature reviewed falls under levels of learning (Kirkpatrick, 1994). It will be discussed in the following order:

- reaction;
- learning;
- behaviour; and
- results.

2.1.2 Category 2: Design studies

The second category of literature surveyed falls under that of design studies. It will be discussed in the following order:

- the concept "design" taken from the definition of the act of designing, as explained by the *RNCS* (Department of Education, 2002);
- drawing and aesthetics in design and technology education programmes, as researched by Garner (Garner *et al*., 1993) and Davies (Davies, 2000);
- the role of aesthetics and drawing in design activities, as researched by Tversky (1999), Anderson (1998) and Press & Cooper (2002);
- classic works on aesthetics and universal visual language (design principles, design elements and design techniques) by Lauer (1985) and Wong (1993) were consulted to inform about the domain specific constructs of aesthetics;

- supporting evidence of the importance of visual abilities in the design process was found in Garner (1994); Parr (2004); Petrina (n.d.) and Worden (2003) ; and
- drawing as tool for visualising conceptual development (Anderson, 1998; Tversky, 1999).

2.1.3 Category 3: CAL in design and technology education programmes

The literature surveyed for category three falls in the category of computer-assisted learning (CAL) material. It will be discussed in the following sequence:

- learning and teaching support material, as required by the South African Department of Education (Department of Education, 2002);
- CAL and electronic teaching and learning support material, as suggested by Alessi and Trollip (2001) and Hannafin and Peck (1988) and the impact that CAL might have on design and technology education (Atkinson, 1998).

2.2 Discussion of the literature survey

The literature surveyed in order to answer the three research questions derived from the main research question, discussed in chapter 3, will now be discussed according to the different categories summarised above.

2.2.1 Category 1: Levels of learning

Kirkpatrick's proposed model for evaluating learning represents a sequence in which instructional programmes can be evaluated (Kirkpatrick, 1994). I used this model (see chapter 1, figure 1.3) as theoretical frame for my research methodology, which is discussed in chapter 3. However, it is important to take cognisance of how Kirkpatrick (1994) defines each of the levels of learning, namely reaction, learning, behaviour and results, in order to understand how I arrived at answering the main research question. In addition to Kirkpatrick (1994), I surveyed a refined way of examining the four levels, as suggested by Alliger *et al.* (1997). The way in which Kirkpatrick (1994) and Alliger (1997) perceive the learning process will now be discussed in an integrated manner.

Kirkpatrick (1994) describes the four levels of learning in his evaluation model (figure 1.3) as representative of a sequence of ways to evaluate instruction and learning support material. Although he acknowledges the importance of each level, Kirkpatrick says, "the process becomes more difficult and time-consuming, but it also provides more valuable information" (Kirkpatrick, 1994, p. 21).

2.2.1.1 Level 1: Reaction

Reaction may be defined as how well learners like instruction and instructional material or parts thereof. In the past, cognitivists explored mental processes from the perspective of cognition rather than affect. However, recent research noted that every sensation gives rise to an affect or emotion (De Villiers, 2002). According to Kirkpatrick (1994) learners' initial reaction to instruction will influence the quality and quantity of learning that takes place. He acknowledges the fact that a positive reaction does not guarantee learning, but argues that a negative reaction certainly reduces its possibility (Kirkpatrick, 1994). A positive reaction would be evident in how much learners "like" instruction. How much they enjoy it; how easy and understandable they find it, will be reflected in affective expressions of general satisfaction (Alliger *et al.*, 1997), which will cultivate a positive attitude towards instructional material. In addition to this, perceived usefulness of instructional material will also contribute to feelings of satisfaction. One way in which learners express their perceptions of its usefulness, is through utility judgements in which they convey their beliefs about the value and usefulness of the instruction, as well as their beliefs about the potential for practical application in related tasks (Alliger *et al.*, 1997).

2.2.1.2 Level 2: Learning

Kirkpatrick considers learning as change on an intellectual level, namely increasing knowledge, developing or improving skills and changing attitudes (Kirkpatrick, 1994). According to him no change in behaviour will occur without learning. For Kirkpatrick increased knowledge refers to the amount of content learned, i.e. concepts and principles mastered; skills refer to improvement of performance and technique, and attitude refers to how positive a person feels towards the training (Kirkpatrick, 1994). Learning can also refer to which principles, facts, elements and techniques were understood and absorbed by learners (Clementz, 2002).

There are different kinds of learning, e.g. momentary learning and temporary retention of knowledge; relevant, unintended learning, acquisition of inert knowledge serving a purpose only when placed into a context and formal learning (De Villiers, 2002; Price, 1998). Alliger *et al* (1997) refined Kirkpatrick's model by referring to immediate knowledge and knowledge retention. He views immediate retention as the amount of knowledge acquired at the conclusion of an intervention, while knowledge retention is considered as the amount of knowledge retained at some point after the immediate conclusion of the intervention (Alliger *et al.*, 1997).

2.2.1.3 Level 3: Behaviour

Behaviour is regarded as the application of a trained strategy within a different context (De Villiers, 2002) as the result of learning (Kirkpatrick, 1994). True learning (transfer) can be considered to have taken place when knowledge and skills learned in one domain are applied in another situation (Osman & Hannafin, 1992). The implication is thus that change in behaviour is constituted by demonstrated transfer and application of knowledge, skills and attitudes in new situations (Kirkpatrick, 1994). Commenting on Kirkpatrick's third level of evaluation, Clark maintains that "behaviour is the action that is performed, while the final results of the behaviour is the performance" (Clark, n.d.). I was, therefore, actually interested in the consequence of the behaviour, i.e. the performance. Alliger, on the other hand, describes behaviour as "demonstrated on the job performance some time after the conclusion of the training" (Alliger *et al.*, 1997 p.6).

According to Kirkpatrick, behaviour cannot change unless learners' have had the opportunity to demonstrate it. He is also of the opinion that it is impossible to predict when a change in behaviour will occur. Change can take place at any time, ranging from immediately after the intervention to a situation where it may never happen. However, behaviour can only change if transfer of knowledge has taken place (Kirkpatrick, 1994).

2.2.1.4 Level 4: Results

Results refer to the achievement of goals of training in terms of reduced costs, higher quality, increased production and lower rates of employee turnover and absenteeism. This level measures the success of the programme in terms that managers and executives can understand. From a business and organisational point of view, this is the overall reason for a training programme, yet level four results are not typically addressed in an educational institution. Determining results in financial terms is difficult to measure, and is hard to link directly to training (Winfrey, 2002). It was not possible to test "results" as it was not appropriate to this study.

2.2.2 Category 2: Design studies

It is generally accepted in design studies that there are four aspects of design, i.e. function, aesthetics, ergonomics and value (Department of Education, 2002; Garratt, 1996; Press & Cooper, 2002). It is also acknowledged that drawing is a core skill to be mastered in design methodology (Davies, 2000; Garner, 1994). The literature surveyed in this category will thus

focus on learning and teaching a universal visual language, the role of aesthetics in design and drawing skills in technology education programmes.

2.2.2.1 The concept "design"

The Department of Education has broken down the act of designing into separate activities, all of which form part of the design phase in the design process suggested in the *RNCS* (Department of Education, 2002):

- understanding the problem;
- writing a design brief;
- generating possible solutions;
- drawing ideas on paper;
- considering several possible solutions;
- applying graphic skills: use of colour, rendering techniques, two-dimensional and three-dimensional drawings, planning, sketching, calculating, modeling;
- managing resources;
- choosing the best solution;
- justifying choices;
- preparing final working drawings; and
- testing, simulating or modelling the solution.

Davies suggests the development of three abilities that can help to empower learners and inform their decision making:

- presenting information in 2-D and 3-D forms;
- selecting symbol systems, language and styles to suit problem contexts and audiences; and
- using the mind and the hand in an integrated way to achieve desired products (Davies, 1996).

The focus of this study will be on drawing and the application of graphic skills and aesthetics, which will be amplified by the discussion of the literature surveyed.

2.2.2.2 Aesthetics and drawing in design activities

The notion of drawing as a modelling device and as a tool for expressing aesthetic principles is not a new one (Anderson, 1998). Drawing decisions in design are based on

recognised representation and presentation techniques, which have emerged into a standard visual language. It shares visual techniques with art (Tversky, 1999), including the realising of design principles by using design elements through the application of different design techniques as summarised in table 2.1.

Knowledge and understanding of aesthetics form an integral part of product design skills as far as it relates to emphasis on the search for a defined user's preferences through market studies and relating methods. This approach is called "market driven aesthetics" (the intention of making the user buy the product). The philosophy behind this approach is that a product is only considered successful once it is valued as being popular by the buyer (Parr, 2004). In the aesthetic language of products, the transmitter of the message is the product itself (Parr, 2004). Parr argues that product aesthetics is an important means of emphasising functional user preferences – in this way aesthetics can be seen as serving functional product requirements as well (Parr, 2004).

Some suggestions for developing a universal visual language to be included in drawing curricula by design educationalists will subsequently be discussed.

2.2.2.3 Universal visual language

Formal aesthetics deal with perceptual references (composition, proportion, colour, etc.) (Anderson, 1998). Some design researchers regard aesthetics as a language providing the necessary rules for synthesising the basic carriers of meaning (the individual design elements of a product, e.g. line, texture, colour, etc.) (Parr, 2004).

Drawings use a small number of segments or elements in varying combinations to produce a potentially infinite set of different drawings. This allows for "peoples' enormous capacity for recognizing many different patterns" (Tversky, 1999). Studying the segments of sketches give insight into which conceptual modules are operative and how they are schematised (Tversky, 1999). These segments in drawings can naturally be analysed according to:

- design principles;
- design elements;
- techniques; and
- ways of arrangement on the format.

These segments are considered standard visual signs that are considered as communication requirements within a domain of its own, although it shares standard and aesthetic rules or principles with art, achieved through the application of design elements (Press & Cooper, 2002). Drawing tasks towards specific design principles, design elements and technique can provide useful information about the segments (Tversky, 1999) in students' schemas (drawings). Table 2.1 summarises the structure for analysing segments in designers' drawings.

Table 2.1 Standard visual language

Construct	
Design principles	unity, balance, scale, proportion, emphasis, rhythm, illusion of space (Lauer, 1985, Wong, 1993)
Design elements	line, shape, size, texture, illusion of movement, colour, tonal value (Lauer, 1985, Wong, 1993)
Design techniques	repetition, addition, omission, distortion, enlargement, diminution (Tversky, 1999)

Referring to teaching and learning a universal language that is used by designers to apply aesthetic design principles, implies the ability of design and technology students to identify and create formal aesthetic properties of a product.

2.2.2.4 Drawing in design and technology education programmes

The existing research data reported on by the literature indicate that, because of its powerful promotion of cognitive processes when designing, drawing should be included as one of the major components of design education (Garner, 1994). The *RNCS* (Department of Education, 2002) emphasises the importance of drawing as a design skill by the repetitive reference to drawing skills as one of the elements in the various steps of the design process, e.g. in investigating, designing and communicating.

Multiple design researchers and technology educationalists have studied the role of drawing in the design process, as well as its role in developing higher order thinking skills and students' problem-solving abilities. A survey of the literature on the re-evaluation of the role of drawing within design activity through case studies done by Garner (Garner *et al.*, 1993), illuminates the cognitive significance of drawing in the design process in technology education. He distinguishes between different types of drawings used in the development of "designerly thought" and its cognitive value (Garner *et al.*, 1993).

Research undertaken by Atkinson (1998) on primary and secondary technology education learners in the United Kingdom confirms the close links between drawing ability and design skills when done within the boundaries of a project, using a design process model (Atkinson, 1998). Her research findings indicated to me that although the majority of learners in her study did not like drawing, finding it tedious, and those learners who produced the best drawings also generated higher quality conceptual ideas.

Research in design education also indicates the importance of drawing ability in the investigation phase where learners use it as a tool to analyse existing designs and to construct understanding of the structure of objects (Anderson, 1998; Garner, 1994) and to enhance conceptual understanding of a design (Atkinson, 1998).

2.2.2.5 Drawing as a cognitive tool

Drawing is, however, more than an expression of aesthetics. Literature indicates that it is known that there is a close link between drawing and designing, and the demands for clarification and development of the role of drawing within design have long been voiced, but rarely met (Garner, 1988). Davies has reported on some research on the role of drawing in design by investigating the real world of product designers. He found that designing requires "the formulation of images in the mind's eye which implies a capacity for mental modeling" (Davies, 1996, p.3). According to Davies reacting to design problems implies thinking about and modeling ideas in order to develop understanding of the range of solutions that might be available (Davies, 1996). Possible solutions can be managed in ways that are relevant to the growth and development of ideas. Imaging means that a universal language or symbol system is used to communicate and convince others of the worth of the solution to the problem.

Drawings are regarded by researchers in the field of visual literacy, as a cognitive tool that can reveal thought and conceptual understanding (Tversky, 1999).
Studies by Anderson (1998) on first year novice designers suggest that exercise and the process of drawing development enhance visual understanding through experiences that further broaden the visual library of shapes, details and potential applications. Arnheim (1954) confirms the importance of visual experiences: "These experiences play a significant role in how we see, recognise, and understand objects. New images come into contact with memory traces of shapes from past experiences that are similar" (Arnheim, 1954 , p.141).

Many design researchers have discussed the role of visualisation in design. Worden says:

> *Visualisation can be part of doing research through the process of designing, where it is then central to methods of generating ideas, or is part of a design process of iteration and reflection. The process of visualisation can be diagrammatically represented or communicated through the production of an artefact that is interpreted through the act of viewing. Drawing is integral to this as are other forms of technical visualisation* (Worden, 2003, p.2).

Many design researchers have also described the act of visualisation. It can be said that in acts of imagining or giving form, visualisation means to make visible, especially to the mind, things not visible to the eye (Worden, 2003).

Anderson's (1998) study on first year novice designers indicated that as a skill, drawing construction helps the student to mentally focus, simplify the structure of visual information and to enhance clarity and understanding.

It appears that there is no clear division between drawing strategies aimed at exploring problems, manipulating information and visualising responses. The implication of this statement by Garner (1993) is that it is difficult for researchers to establish accurate and concrete proof of exactly what takes place during investigating and designing (presenting possible solutions). In addition to the extremely complicated set of cognitive processes interrelated when drawing for design purposes, Garner (1993) reports on skilled designers being able to produce drawings that have multiple functions and, more importantly, functions that apparently take place simultaneously. It is, therefore, possible that a designer can produce a drawing that may have been made to externalise a private and incomplete idea, which at the same time can function as the communication of form, detail, scale, shape, colour, etc. The same drawing may also facilitate evaluation and at the same time provoke further generation of ideas (Garner *et al.*, 1993).

In order to achieve conceptual understanding, the student has to be skilled in observation, analytical thinking and critical thinking, applying knowledge and skills (Davies, 1996). Anderson indicates that design drawing represents conceptual understanding of a design problem, which clarifies an idea sufficiently so as to offer specific intent (Anderson, 1998). This implies that the learner demonstrates his or her understanding of the conceptual relations between the problem and possible solutions through drawings.

2.2.3 Category 3: CAL in design and technology education

In order to answer research questions 1 and 2, the third category of literature surveyed focused on the development of learning support material for the purpose of design and technology education purposes, with specific focus on the use of computer-based interventions in technology education programmes.

In this section I surveyed literature clarifying the following:

- introduction to CAL in educational programmes;
- CAL in teaching and learning design and technology in general; and
- CAL in teaching and learning specific knowledge and skills in design and technology education.

The policy document, *Teacher's Guide for the Development of Learning Programmes for Technology,* states the following:

> *Learning and Teaching Support Materials have a very important role to play in the learning of Technology. They provide the medium through which teaching and learning happens at school…Among other things, they provide opportunities for learners …to:*
>
> - *Develop skills, knowledge, values and attitudes as underpinned by Learning Outcomes and their corresponding Assessment Standards in the Technology Learning Area Statement.*
> - *Do research in various areas of Technology*.
>
> and
>
> *Learning and Teaching Support Materials in Technology include … Reference Materials – i.e. textbooks, encyclopaedias, electronic reference media* (Department of Education, 2004, p.51).

The theoretical underpinnings for evaluating and selecting learning and teaching support materials were founded on the policy document, *Teacher's Guide for the Development of Learning Programmes for Technology*, (Department of Education, 2004):

- learner centeredness;
- cooperative learning;
- appropriateness of learner activities to learners' cognitive development;
- contextualisation of activities;

- assessment guidelines; and
- affordability.

It is within this broad theoretical field of developing learning support material that the focus of this study falls on the development of electronic reference media to support the development of design skills, knowledge, values and attitudes and to do research in various areas of technology.

2.2.3.1 A strategy for teaching and learning drawing in technology education

Academics and practitioners in the Western World have considered theories of learning and instruction in order to develop effective learning, particularly since the 1960s. Instructional theory studies methods of facilitating human learning and development to "help people learn better" (De Villiers, 2002). Instructional and learning theories are concerned with formal learning. Basic instruction is predisposed to the pragmatic simplification of phenomena and associated isolation of aspects of a domain. Methods of communicating information are proposed to help learners apply knowledge, to integrate learning and to transfer it to complex domains (De Villiers, 2002).

Evaluating learning support material (contextually integrated learning support material) as category of instructional material can be complicated as it may lead to discussions without clear isolation of courseware components. Studying the educational and pedagogical value of any support material can, therefore, not be done without considering the whole context in which it is implemented. The question to ask is "under which conditions is the learning support material valuable"? The type of technology (media), the type of student and the particular conditions (learning environment) involved, as well as the dynamic interrelations between all these factors, have to be considered when evaluating learning support material (Poole, 2001).

Alessi and Trollip maintain:

> *If we were to chart out all the instructional topics, the wide variety of learners, and the many instructional situations, we would sometimes find an advantage for books, sometimes teachers, sometimes film or video, sometimes peer-tutoring, sometimes hands-on field experience, sometimes listening to an audiotape, and sometimes computers. Not surprisingly, across these many studies, which utilized a variety of topics, learners, and*

> *situations, little or no overall effect was found in favour of a single medium* (Alessi & Trollip, 2001, p.10).

Alessi and Trollip continue:

> *To take advantage of the computer's particular capabilities and not to waste them, our first rule for correctly using or developing instruction to be delivered via computer is to do so in situations where the computer is likely to be beneficial* (Alessi & Trollip, 2001, p.10).

According to Poole the question which needs to be asked and answered when assessing (computer) technology's impact in education, is "what added value does technology bring to the classroom?" (Poole, 2001). The implication of the above statements is that critical evaluation of the appropriateness of learning support material and the suitability of the medium in which it is implemented, should be made.

In order to critically evaluate the suitability of computer assisted learning support, its usability and effectiveness should be tested. Usability testing is described as "a dynamic process that can be used throughout the process of developing interactive multimedia software" (Lee, 1999b, p2). The purpose of usability testing is to find problems and make recommendations to improve the utility of a product during its design and development. For developing effective interactive multimedia software, dimensions of usability testing were classified into the general categories of learnability; performance effectiveness; flexibility; error tolerance and system integrity; and user satisfaction. In the process of usability testing, evaluation experts consider the nature of users and tasks, tradeoffs supported by the iterative design paradigm, and real world constraints to effectively evaluate and improve interactive multimedia software. According to Lee (1999b) software should be simple to use, simple to understand, yet still powerful enough for the task.

Numerous studies have shown that interactive video, CD-ROM storybooks, computer-based drill and practice and tutorials can be powerful instructional tools. Computer-based tutorials are described as programs providing "some information or clarifies certain concepts in addition to providing the student with practice exercises" (Soe *et al.*, 2000). The implication is then that the computer can begin to take over actual instructional functions, adapted to the student's individual level of accomplishment.

Alessi and Trollip (2001) have identified the purpose of computer-based tutorials as the presentation of information to learners and the guidance through the initial use of the content. A tutorial (or self-study guide), therefore, comprises the following attributes:

- it presents factual information and model skills;
- it guides learners through the initial use of information;
- information is queued according to learner's abilities;
- it motivates the learner; and
- the locus of control should be with the learner (Alessi & Trollip, 2001).

There are two types of structures for computer-based tutorials, namely linear tutorials and branched tutorials. This is the simplest type of programming in tutorials. The tutorial progresses from one topic or concept to the next, presenting information and asking questions. Although this structure is commonly used, it does not take full advantage of the capabilities of computer-based instruction as it does not adapt to individual learners' needs (Alessi & Trollip, 2001).

2.2.3.2 The use of CAL in technology education

The integration of educational software designed for integration in the domain of technology education, has recently been emerging worldwide. Computer Aided Learning (CAL) in technology education programmes as tool to facilitate learning is seen as particularly attractive as a means of stimulating technological activity providing learning at a point of need, and to bring design contexts into the classroom (Hodgson, 1994). The potential value of the computer in a number of specific categories of activities relating to design and technology, namely graphics, modelling, manufacture, control and information use is currently being investigated by researchers in the field (Hodgson, 1994).

According to Atkinson (1998), CAL systems typically simulate activities, instruct or reveal information – usually with a specific educational purpose in mind. The pedagogical advantages of CAL have all been well researched (Alexander, 1995; Atkinson, 1998; Ford, 1999; Lee, 1999a). Benefits have been reported in terms of individualised learning that can be self-paced, self-accessed, asynchronised, synchronised or in real time modes, provide non-sequential based delivery and include positive motivation interactive features.

Hodgson (1994) identifies examples of support that CAL, specifically in design and technology, may provide:

- bringing real design situations and contexts into the classroom;
- simulation of technological activity and so moving more rapidly and effectively towards a design outcome; and
- information or instruction at the point of need.

2.2.3.3 Suitability of Microsoft PowerPoint™ as platform for a tutorial

Some authors regard Microsoft PowerPoint™ as a suitable platform for tutorials because of its capacity to be programmed in a linear way as well as to branch. This versatility can, therefore, be utilised to suit the particular needs of the learners (Montgomery & Wiley, 2004). Microsoft PowerPoint™ has traditionally been used as an educational tool for live presentations supporting presenters' spoken message. It has been criticised harshly by audiences, students and researchers for a number of reasons (Rozaitis, 2004). Some critics claim that Microsoft PowerPoint™ lends itself to abuse to the extent that it in fact leads to less effective rather than more effective communication. Taylor recorded a student commenting on a lecturer using Microsoft PowerPoint™ as saying: "It can take away from the teaching. If the notes are in paragraph form, I can't focus on what's important, and I don't pay attention to the lecture" (Rozaitis, 2004; Taylor, 2003).

Microsoft PowerPoint™ has also been criticised for causing boredom of audiences to the extent of "death by PowerPoint" caused by its simplified linearity, lack of interactivity, bulleted telegraphic text repeated by the presenter, the tendency to present facts through misleading graphs and irritating animations and presenters focusing on visual effects contributing nothing to the quality of the content (Norman & Spohrer, 1996). However, Microsoft PowerPoint™ has several advantages that make it particularly suitable for conveying the dynamics of visual material because of its capacity to deliver high quality graphic representations as well as advanced branching programming possibilities (Weiser 2003). It is the branching ability that makes it particularly suitable for the purpose of a self-study guide, namely interactive asynchronous use, self-paced, undirected individual and independent learning.

2.2.3.4 Tutorials

There are different kinds of learning, e.g. momentary learning and temporary retention of knowledge; relevant, unintended learning; acquisition of inert knowledge serving no purpose until placed into a context; and formal learning (De Villiers, 2002). A learning strategy is an individual's approach to complete a task. More specifically, a learning strategy is an

individual's way of organizing and using a particular set of skills in order to learn content or accomplish other tasks more effectively and efficiently in school as well as in non-academic settings (Schumaker *et al*., 1984).

In order to make effective use of an electronic self-study guide, the software must allow for the individual needs of the learners. It should be presented and programmed in such a way that learners are motivated, enjoy what they are doing and learn effectively. The efficient instructions should be clear to allow for undirected use. The focus should be on learners constructing own knowledge and understanding of the domain specific content (Schumaker *et al*., 1984).

2.3 Overview of the literature relating to the theoretical underpinnings of this study

Experts in the field of design and technology education indicated that one of the most effective strategies in teaching and learning technological literacy and conceptual understanding is through the design process. The design process is also regarded as a strategy for solving problems in a systematic and non-threatening way. It was also found that there are many models of the design process, both linear and iterative in nature. The focus area of the literature surveyed was on the role of visualisation through drawing in the design process and the extent to which computer-based educational software designed towards the understanding of aesthetic design principles enhanced the design abilities of design and technology education students. Several usability studies of educational software were found, but the focus in this study is on the simplicity of use, simplicity of understanding and its power to accomplish the set learning outcomes.

In this chapter, a survey of the literature, definitions of key concepts and an integrated discussion of the literature were given. In the following chapter, the design and methodology followed during the fieldwork and the motivation for selecting the qualitative research method will be documented.

3.1 Introduction

This is an initial report in a series of formative studies of instructional design in a design and technology education context conducted within the qualitative framework of a case study. In this chapter I will describe and discuss the research methodology followed; how the research was conceptualised; how it was designed; and subsequently, the sampling methods; data sources, data collection methods; data capturing and editing; how it was analysed and interpreted and reported on. I will conclude by discussing the strengths and weaknesses of the research.

The research questions

The main research question to be answered in this study is:

What was the role of the tutorial, *Design in Action* (a computer-aided tool), in Kirkpatrick's three levels of learning in a first year design and technology education programme?

Three research questions and its sub-questions were derived from this question:

Research question 1: What are the implications of the participants' reaction to the tutorial with regard to the possible improvement thereof?

Sub-question 1: Were the participants satisfied/dissatisfied with the tutorial?

Sub-question 2: What was the perceived usefulness of the tutorial?

Sub-question 3: What in the tutorial were the participants dissatisfied with?

Research question 2: What are the implications of the participants' retention of knowledge with regard to the possible improvement of the tutorial?

Sub-question 1: What knowledge was retained immediately after exposure to the tutorial?

Sub-question 2: What knowledge was retained after some time?

Research question 3: What are the implications of the participants' behaviour/ transfer with regard to the possible improvement of the tutorial?

Sub-question 1: How was knowledge transferred to participants' designs for their projects?

Sub-question 2: What was the sustained change in behaviour in the end-of-year examination?

The findings resulting from the sub-questions above are discussed and answered in detail in chapter 4 and, result in conclusions about the following:

- how the processes of instructional design, development and evaluation in the tutorial can be improved;
- the extent to which the theoretical concepts and principles of learning and instruction inform instructional design practice in productive ways; and
- the way in which theoretical ideas of the designer of *Design in Action* enhanced its development through testing in a classroom setting (Van den Akker, 1999).

3.2 Methodology

The research goals of this study can be classified according to two sets of goals, namely interpretavist and development. The interpretavist goal focuses on "portraying how education works by describing and interpreting phenomena related to teaching, learning, performance, assessment, social interaction, innovation, and so forth" (Reeves, 2000). The development goal focuses on "the dual objectives of developing creative approaches to solving human teaching, learning, and performance problems while at the same time constructing a body of design principles that can guide future development efforts (Reeves, 2000). The reason why I used an interpretive methodology is that its approach is flexible and allowed me to follow a research methodology for qualitative research that could be defined as "multi-method in focus, involving an interpretive, naturalistic approach to its subject matter" (Denzin & Lincoln, 1994, p.2). I used multiple methods and strategies to gather information (see figure 3.1) in order to gain a holistic view of the levels of learning achieved by participants in this study and to collect meaningful data in the "natural" (Cohen *et al.*, 2000) learning environments of the students involved.

Due to the integration of the research in the natural chronological flow of the module under discussion, the methods selected were dependent on the scheduled contact time of the class involved. It was further dependent on the pace at which the whole group worked in this project-driven module. Therefore, flexibility was one of the most advantageous attributes of the qualitative interpretive approach to this study. At the outset of the research, I was uncertain about the exact number of participants who would be available for the duration of the study.

Evaluating learning of aesthetic design theory is a complex task due to the vast number of ways in which knowledge and understanding can be revealed through visual analysis and drawing (Anderson, 1998; Tversky, 1999). Reporting on the evidence, such revelation could

not be done in numerical or statistical terms, but I needed to do so through rich and vivid descriptions and explanations of what was revealed. In addition, the complexity of the domain specific content and the numerous possible interrelationships between the different constructs, forced me to describe the evidence in the data while at the same time analysing it. It was not possible to make simplistic analyses and reach direct and linear conclusions. In order to crystallise evidence and interpretation I had to design multiple strategies for evaluation. This led to richness of data, which I endeavoured to portray in my report of the events (see chapter 4).

According to Cohen, the interpretive approach is well suited for the case study. "Case study" can be defined as "a specific instance that is frequently designed to illustrate a more general principle" (Cohen *et al.*, 2000). I will argue that repeated implementations of this study with different groups could lead to the formulation of general principles about the learning of aesthetic design theory with the integration of electronic tutorials in learning programmes.

Key issues were drawn from a rigorous examination of three instances in the data to detect meanings relevant to the research questions. These issues were analysed and described in a thick and rich manner, supported by evidence from the data. In this way I could penetrate the learning of design theory in ways that would not be "susceptible to numerical analysis" (Cohen *et al.*, 2000). I then categorised information and findings into naturalistic patterns that could be applied to similar cases (McMillan, 2001). In this way I generalised by applying features from the case study under discussion to various classes with the same features. Qualitative approach is, therefore, suitable for this study as

- it is flexible;
- it is concerned with a rich and vivid description of events relevant to the case;
- it blends a description of events with the analysis thereof;
- it highlights specific events that are relevant to the case;
- the researcher is integrally involved in the case;
- an attempt is made to portray the richness of the case in writing up the report;
- theory can be deducted by applying features from a single case to a multiplicity of classes with the same features (Cohen *et al.*, 2000).

I based my research on the number, the form and chronological order of the different evaluation opportunities allowed by the module. The flow of the research plan is illustrated in figure 3.1.

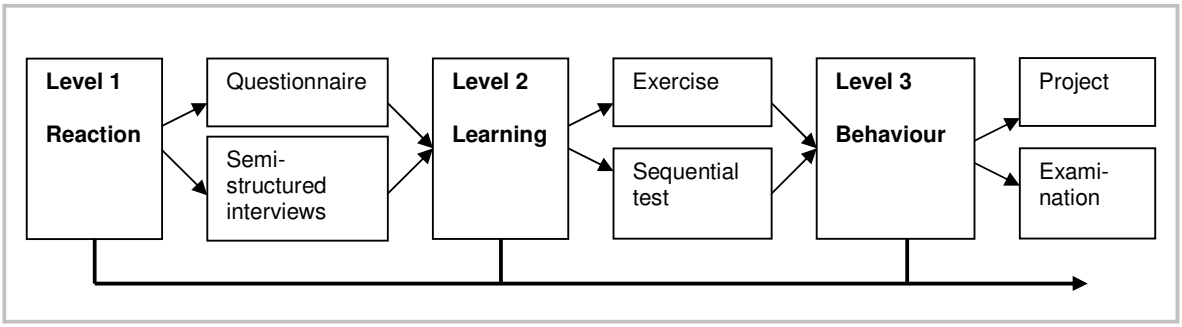

Figure 3.1 The research plan

In the discussion that follows, I will describe and explain the theoretical framework, population and sampling methods, data generating strategies, implementation of data generating strategies, data capturing, data analysis, validity and reliability and limitations of the study. Descriptions and explanations include visual representations of tables, flow charts, and integrative diagrams.

3.3 Theoretical framework

This qualitative case study, including the evaluation of levels of learning of first year pre-service design and technology teachers, was conducted in the interpretive paradigm, within the theoretical frame of socially responsible research (Reeves, 2000). Socially responsible research implies that "prescriptions are provided with useful solutions for a variety of design and development problems in education" (Van den Akker, 1999, p.6). The concept "socially responsible research" refers to a systemic approach to research of which the purpose is to seek a fundamental understanding of the nature of instructional design. Socially responsible research is further concerned with the practical use of the research findings and with understanding "how" instructional technology improves education (Reeves, 2000). According to Van den Akker, one of the possible approaches followed to conduct socially responsible research, is that of development research. It is acknowledged that "development research" has been used to refer to various kinds of research approaches that are related to design and development work (Van den Akker, 1999). Development research will be defined for the purpose of the two sub-domains relevant to this research, namely media and technology and learning and instruction:

- In media and technology the ultimate aim of development research is improving instructional design practice, its development and evaluation thereof.
- In learning and instruction it involves the research that includes developmental work in designing learning environments, formulating curricula, and assessing achievements of

cognition and learning. Simultaneously it endeavours to play a part in fundamental scientific understanding (Van den Akker, 1999).

Van den Akker maintains that one general aim of all development research is reducing the uncertainty of decision making in designing and developing (educational) interventions. Two more specific goals that apply to development research in various degrees are:

- providing ideas (suggestions, directions) for optimising the quality of the intervention to be developed; and
- generating, articulating and testing design principles [4] (Van den Akker, 1999).

It thus seemed possible to consider researching an intervention from an evaluation point of view, with the aims being the improvement of the intervention and generating of design principles. This research could thus be regarded as socially responsible research with a developmental research approach (figure 3.2).

The evaluation of the levels of learning was based on a model designed by Kirkpatrick (1994). The model delineates four levels of instruction (training) outcomes: reaction, learning, behaviour, and results (see figure 1.3 in chapter 1). Level 1 includes assessment of participants' reaction to or general satisfaction with the instruction, including affective responses to the quality and the relevance of the instruction. Level 2 refers to indicators of the learning that has taken place during the course of the programme. Level 3 addresses the extent to which knowledge and skills gained in training are applied. Level 4 intends to provide the extent of the impact that the instruction has had on broader organisational goals and objectives. This study does not include level 4 as it is not relevant to the educational context within which the instruction was applied (Winfrey, 2002).

[4] Principles can be of a "substantive" nature, referring to characteristics of the intervention (what it should look like), or of a "procedural" nature (how it should be developed) (Van den Akker, 1999).

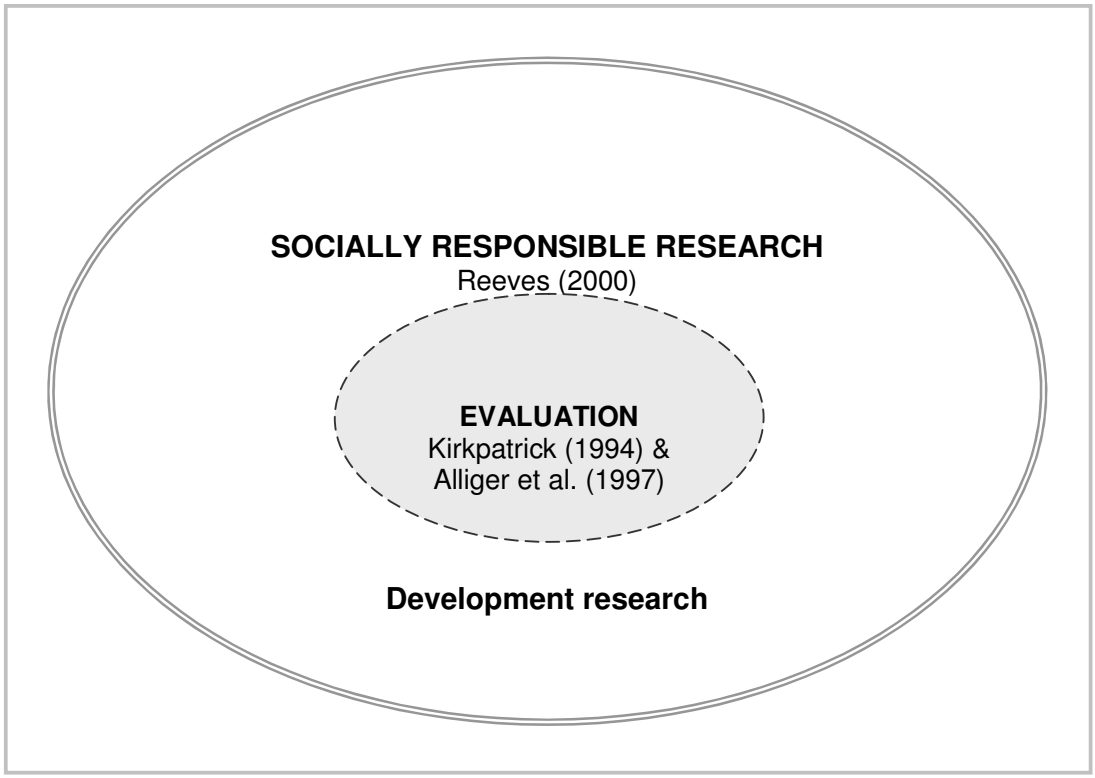

Figure 3.2 Theoretical framework of the research

The reasons why I wanted to establish the levels of learning that took place through integrating the electronic tutorial into the programme are twofold. Firstly, I wanted to establish the limitations inherent to the design of the tutorial, with the aim of improving the design. Secondly, I wanted to establish the extent to which it contributed to learning the domain specific content of the module, with the aim of improving the integration thereof, while at the same time, constructing a body of design principles that could guide future development efforts (Reeves, 2000). This puts this research within the frame of "socially responsible research".

Kirkpatrick's model for evaluating the levels of learning has been widely accepted as a useful means for instructors to "couch" the outcome of programmes or interventions (Alliger *et al.*, 1997). According to Kirkpatrick, the four levels "represent a sequence of ways to evaluate" interventions (Kirkpatrick, 1994). The reasons why I found it useful for developing my research were twofold. Firstly, it could address my need to understand the evaluation of an intervention in a systematic way. Secondly, it had the potential of simplifying the complex process of evaluating intervention in the following way:

- The model represented a straightforward guideline regarding the kinds of questions that should be asked and the criteria that might be appropriate.
- The model reduced the measurement demands for evaluating the intervention.
- The model focused the evaluation process on four classes of outcome data that could be collected after the intervention was completed – it seemed to eliminate the need for pre-tests.
- As conclusions about the effectiveness of the intervention would be based on outcome measures only, the model greatly reduced the number of variables with which intervention evaluators normally are concerned.
- The model eliminated the need to account for the complex network of factors that interact with the intervention process (Alliger *et al*., 1997).

Other researchers in the field have recognised the contributions of Kirkpatrick's model to intervention evaluation thinking and practice (Alliger *et al*., 1997). Those relevant to this study can be summarised as follows:

- it has helped to focus evaluation practice on outcomes;
- it has fostered the recognition that single outcome measures cannot adequately reflect the complexity of instructional programmes;
- it underscored the importance of examining multiple measures of instructional effectiveness;
- the distinction between learning (level 2) and behaviour (level 3) placed the emphasis on the importance of the learning-transfer process in making the intervention effective.

In spite of the advantages of Kirkpatrick's (1994) model, one of the limitations was evident at the beginning of this research, namely the oversimplified view of the levels of learning (Bates, 2004). In this research I used Alliger *et al*'s (1997) augmented version of Kirkpatrick's model (1994), which refines the way in which the levels are evaluated (table 3.1). Other limitations encountered during the course of the research, and which correspond with those reported in the literature review, will be discussed in section 3.10 of this chapter.

The reasons for selecting development research as approach for this study, are threefold: Firstly, it allowed me to address complex problems in a real context of a relatively new learning area in South Africa, namely technology education. I attempted to establish how to cope with the complex problems in the real context of the task of developing contextually integrated learning support material. The information gathered during the research period of

this study using the tutorial as intervention, will be used to inform the improvement of the tutorial and implementation during the programme.

Table 3.1 Adaptation of Alliger's augmented version of Kirkpatrick's model for evaluation (Alliger *et al.*, 1997)

Level	Criterion	Definition
Level 1 Reaction:	Affective reactions	Participants' perceptions of the intervention – generally their satisfaction with the training
	Utility judgments	Participants' belief about the value and usefulness of the training; the extent to which they believe they will use the knowledge and skills in other relevant situations
Level 2 Learning:	Immediate retention	The assessment of knowledge acquisition at the conclusion of the intervention
	Learning after a period of time	The retention of knowledge at some point after the immediate conclusion of the intervention
Level 3 Behaviour:	Transfer of knowledge and skills	Demonstrated performance after a period of time
	Sustained performance	Demonstrated sustained performance after a period of time

Secondly, it allowed me to conduct rigorous and reflective inquiries to evaluate and refine innovative learning environments as well as to define new design principles. I could establish the pedagogical value of the intervention within the context of the learning environment of the module by examining the levels of learning in the domain specific context of the aesthetic aspect of design, governed by specific constructs, namely design principles, elements and techniques made visible through universal visual language (Anderson, 1998; Tversky, 1999).

Thirdly, I could suggest direct pedagogical benefits (improvements to the tutorial as well as to the integration thereof in the programme) to all stakeholders (lecturers and students) within the context of the research (Van den Akker, 1999).

I have indicated the many hallmarks of the qualitative research paradigm and subsequent reasons for selecting it as approach to this study. However, the qualitative interpretive approach inherently has many attributes endangering the validity and reliability of a study (Cohen *et al.*, 2000). Strategies for ensuring validity and reliability for qualitative research sought in this study will be discussed in an integrated manner in the following section, and is summarised in section 3.9 of this chapter.

3.4 Population and sampling methods

At the outset of module JOT120, the sixty students who were registered for the course were invited to volunteer to take part in a trial run of the tutorial, *Design in Action*. Only 22 students volunteered to participate in the trial run. From this group, three participants were

selected as a focus group. The choice of these participants was restricted to those who indicated their availability for the entire duration of the study, which would include two weeks after the completion of the students' year-end examination. Many students indicated that they would not be available after their last paper. Others were uncertain about their availability. In the end, only three students committed themselves for the entire duration. Their profile can be summarised as:

- first year female pre-service teachers[5];
- no previous exposure to formal design and technology activities;
- diverse drawing skills;
- no previous exposure to visual analysis of existing designs;
- diverse exposure to the concepts covered in the tutorial;
- diverse experience in computer-assisted tools; and
- diverse experience in Microsoft PowerPoint™.

After selecting the sample, I decided which data generating strategies could be implemented within the normal course of the module that would provide me with relevant information for answering the research questions. The strategies decided on as well as the reasons for my decisions, will now be discussed.

3.5 Data generating strategies

Evaluating the tutorial would require finding evidence of how learning took place within the context of the intervention. Evidence should be found in elements of the intervention catering for a positive attitude towards the tutorial, individual understanding of the content, reinforcement of knowledge and the opportunity to transfer knowledge in a new contextually relevant situation.

The effectiveness of the tutorial would be evident through the levels of learning revealed in the different strategies. On level 1 (reaction) participants were subjected to a questionnaire establishing their general satisfaction with and perceived usefulness of the tutorial. The findings were subsequently supported by semi-structured interviews eliciting confirmation and more detail. On level 2 (learning) participants were subjected to an exercise immediately after the first exposure to the tutorial in order to establish their immediate retention of the content. To support the findings, as well as to establish learning after a period of time, a sequential test was conducted two weeks later. On level 3 (learning) the

[5] Two of the three participants' first language was Afrikaans. For this reason their responses to most of the data generating instruments were in Afrikaans which were translated for the purpose of this research.

evidence of the project conducted on a continuous basis were validated by evidence in the end-of-year examination. Each strategy, its characteristics and reasons for utilisation will now be discussed.

On all levels of learning I looked for evidence of levels of learning of the design process, understanding of the nature of design principles, elements and techniques through visual analysis of designs, and mastering of exploratory drawing skills achieved by the participants. Therefore, data were analysed in such a way that I could establish the extent to which the intervention contributed to learning on the different levels.

3.5.1 Level 1: Reaction

In this section I will describe how two strategies, the questionnaire and the semi-structured interviews contributed to generating data in the form of affective reactions and utility judgements.

3.5.1.1 The questionnaire

From table 3.2 it can be seen that seven open-ended questions were asked to establish participants' affective reaction, which would indicate what participants enjoyed/liked and whether they found the tutorial easy to use or not.

Table 3.2 Questions in the questionnaire evaluating reaction

Level 1		**Information sought**	**Question***
Affective reaction	General satisfaction	• Did the trainees like and enjoy the training? • Was it easy? • Were the participants comfortable using the tutorial? • Did participants understand how to work with the tutorial?	Question 1: "What did you like most about the tutorial?"
Utility judgments	Perceived usefulness	• Did the participants consider the training relevant? • What was the perceived practicality and potential for applying the knowledge and learning? • Was it worth their while?	Question 5: Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design? Question 9: Which aspect of the design theory in the tutorial did you understand the least? Question 11: Did you manage to complete the exercise in time? Question 12: Which aspect of design theory did you learn most about through the use of the tutorial?

Level 1		Information sought	Question*
Affective reaction	Dissatisfaction	• Which aspects of the tutorial did participants not like?	Question 2: What would you have liked different in the tutorial? Question 3: What did you like least about the tutorial?

*Question numbers refer to the questions as sequenced in the questionnaire.

Responses could refer to participants' experiences, forming of constructs, feelings and knowledge elicited during the intervention with the tutorial. Questions 1 to 4 were aimed as establishing participants' utility judgements and eliciting reactions to participants' individual and subjective perception of the usefulness of the tutorial. Question 5 was aimed at the relevance of the tutorial to other modules in the design and technology programme as well as to its practicality and potential for application in other situations. Questions 9, 11 and 12 gave participants the opportunity to reflect on what they had learned from the tutorial. From the responses to these questions I could infer whether participants regarded completing the tutorial as time well spent. The questions were asked in such a way that it would be easy to classify the answers through content analysis.

3.5.1.2 The semi-structured interviews

The same questions as in the questionnaire were used during the semi-structured interviews as probes and prompts enabling the participants to elaborate, provide detail and qualify their responses (Cohen *et al.*, 2000). A structure for the interviews, consisting of six questions based on those in the questionnaire was prepared. Informal prompting and probing questions were added when more specific information was needed. I noted these probing questions and prompting, as well as the participants' responses, during the conversations. These notes were later captured as an electronic document. Table 3.3 indicates the two types of reactions Alliger et al. (1997) identified on level 1, namely affective reactions and utility judgments.

Table 3.3 Questions in the semi-structured interviews generating data about reaction

Level 1		Information sought	Question*
Affective reaction	General satisfaction	• Did the trainees like and enjoy the training? • Was it easy? • Were the participants comfortable using the tutorial? • Did participants understand how to work with the tutorial?	Question 1: "What did you like most about the tutorial?"
Utility judgments	Perceived usefulness	• Did the participants consider the training relevant? • What was the perceived practicality and potential for applying the knowledge and learning? • Was it worth their while?	Question 4: Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design? Question 5: Which aspect of the design theory in the tutorial did you understand the least? Question 6: Did you manage to complete the exercise in time? Question 6: Of which aspect of the design theory did you learn most through the use of the tutorial?
Affective reaction	Dissatisfaction	• Which aspects of the tutorial did participants not like?	Question 2: What would you have liked different in the tutorial? Question 3: What did you like least about the tutorial?

* Question numbers refer to the questions as sequenced in the semi-structured interviews

Alliger *et al*. (1997) confirms the importance of utility reaction measures closely related to the content of the training for ensuring validity. Those aspects participants indicated as the ones they had learned most about, indicated to me that they considered the tutorial useful supporting them to learn about certain design aspects. I learned from the responses to the questionnaire and semi-structured interviews that participants perceived the tutorial as useful, and, therefore, considered their time well spent due to the tutorial's

- relevance to the module;
- usefulness to other modules; and
- practical applicability.

3.5.2 Level 2: Learning

In this section I will discuss the two strategies implemented to generate data regarding learning immediately after the intervention on level 2, namely the exercise and the sequential test.

3.5.2.1 The exercise

The exercise consisted of fifteen questions requiring of participants to visually analyse given designs and explain the operational relations between the different constructs, i.e. design principles, design elements and design techniques. In order to do this, they had to "take apart each design" or "break down each design into component parts to understand its structure" (Bloom, 1956).

A combination of directed and undirected open-ended questions was set in the exercise and in the test. The purpose of this was to allow for the students' enormous capacity to recognise many different visual patterns (Tversky, 1999). Thus, a number of possible responses could be correct. The way the test was designed to generate data relevant to this aspect of the research, will now be discussed.

Participants' knowledge of the constructs would be evident in their choice of terminology appropriate to the specific design. Their skills would be seen in the degree of specificity in which they achieved the required cognitive activity required in the questions:

- identify/name;
- describe;
- explain; and
- critically discuss.

From table 3.4 it is clear that the three questions of the exercise discussed further on, established participant's immediate retention. It is also clear that these three questions in the test measured participants' retention of specific design principles and elements after a period time.

Table 3.4 The exercise: Learning assessed immediately after training in questions relating to visual analysis*

	Sub-level	Information sought	Question**
Visual analysis	Immediate retention	• What did participants learn about the design principles "balance, unity, scale" and "proportion"? • What did they learn about the design elements "texture" and "illusion of motion"? • What techniques could they identify and relate to the principles and elements?	Question 2: Name the type of balance achieved in this design. Describe the elements used to achieve this type of balance. Question 9: Discuss the way in which the illusion of movement is created in this design. Question 12: Discuss how the element of texture and the principle of proportion bring interest to the design.

* See Addendum 6

** Question numbers refer to the questions as sequenced in the exercise

To establish their immediate retention, a total of fourteen designs were presented to the learners at the end of the tutorial and on hard copy (see Addendum 5). For the purpose of this study, responses to only three exercises were analysed and are discussed in chapter 4.

3.5.2.2 The sequential test

Three test questions requiring participants to analyse different designs and three questions requiring participants to demonstrate their understanding of some constructs through free-hand drawings, generated information about learning after a period of time. The test questions requiring participants to do visual analysis and the information I sought are indicated in table 3.5. The same coding system for evaluating visual analysis in the test was used for the exercise (See table 3.14 for the coding system used). For the analysis of the data generated in the test, see chapter 4.

3.5.3 Level 3: Behaviour

The strategies implemented to generate data on behaviour, namely the project and the examination will now be discussed.

3.5.3.1 The project

For the purpose of this study "behaviour will be considered as 'performance' " (Clark, n.d.). In the context of the project, the knowledge revealed through participants' drawings, was considered as part of their performance. The project requirements relevant to this study were to:

- consider aesthetic design principles as part of the solution to a problem; and
- make representational drawings of their intentions of the conceived solution.

Table 3.6 indicates the problem statement as formulated for the project.

Table 3.5 The test: learning assessed after a period of time revealed in questions relating to visual analysis as well as in drawings

Questions relating to visual analysis			
	Sub-level	**Information sought**	**Question***
Visual analysis	Learning after a period of time	• What did participants learn about all the design principles? • What did they learn about all the design elements? • What techniques could they identify and relate to the principles and elements?	Questions 5.1, 5.2 and 5.3: Identify all the design principles achieved in each of the designs below.

Questions relating to drawings			
	Sub-level	**Information sought**	**Question**
Drawing	Learning after a period of time	• What did participants learn about the design principle "unity"? • What did they learn about the design elements "shape, size, pattern, tonal value, line" and "texture"? • What techniques could they identify and relate to the principles and elements?	The test Question 1: Illustrate the design principle "unity" achieved through shape and pattern. Question 2: Illustrate the design principle "asymmetrical balance" achieved through size and tonal value. Question 3: Illustrate the design principle "visual texture" achieved by line, tonal value and shape.

* Question numbers refer to the questions as sequenced in the exercise (see Addendum 6)

The problem statement for the project was open-ended and undirected. No suggestions to the realisation of particular design principles were made, other than an implied requirement that students should realise as many principles and use as much design elements as possible. While in the developmental stage of the designs, designs were assessed on a continuous basis. The representational drawings that have not been assessed on a summative basis will be presented and analysed in chapter 4.

The data gathered on research question 3, which were captured through drawings for the students' projects and end-of-year examinations, were analysed in the same way and with the same coding system (table 3.14) used for analysing the drawings on level 2 (figure 3.7). In the representational drawings for the project I looked for evidence of application and transfer of knowledge tested on level 2. The same aspects as for the examination indicated in 3.5.3.2 were evaluated. See chapter 4 for the analysis.

Table 3.6 Problem statements posed to students in the project

	Sub-level	**Information sought**	**Problem statement**
Drawing	Transfer of knowledge	• How well did the drawings reveal the design elements and techniques used to realise design principles? • Was there sufficient clarity? • How well did it represent the idea? • Was there sufficient visual interest created through variety?	Design and make a lighting system suitable for a specific need you have identified, considering all four design aspects, functionality, aesthetics, ergonomics and value. (For the purpose of this study, only realisations of aesthetic aspects are relevant and will be discussed.)

3.5.3.2 The examination

One of the questions in the end-of-year examination was relevant to this study. Students were required to visualise how some aesthetic design principles specified in the paper could be incorporated in the design of a lamp. In these designs I looked for evidence of sustained performance. Table 3.7 indicates that the problem statement in the end-of-year examination

was more directed, specifying specific design principles to be realised and design elements to be used.

Table 3.7 Problem statements posed to students in the end-of-year examination

	Sub-level	Information sought	Problem statement
Drawing	Sustained change in behaviour	• How well did the drawings reveal the design elements and techniques used to realise design principles? • Was there sufficient clarity? • How well did it represent the idea? • Was there sufficient visual interest created through variety?	Design a freestanding lamp which includes the following: • asymmetrical balance; • visual unity between the base and the shade; and • contrast achieved through visual texture. The lamp must also provide soft, intimate background lighting. (For the purpose of this study, this item was not relevant and will not be discussed).

In the preliminary drawings for the examination I looked for evidence of sustained performance. In both instances the drawings were carefully examined and re-examined in order to establish the following:

- How well did the drawings reveal the design elements and techniques used to realise design principles?
- Was there sufficient clarity?
- How well did it represent the idea?
- Was sufficient visual interest created through variety?

In the project and the examination the design theory had to be applied to a 3-D object, namely an electrical lamp, and not only to an abstract 2-D schema. The following aspects of performance were evaluated:

- knowledge of the different components;
- skills in analysing a design;
- increased detail;
- increase in specifics;
- sharpness in seeing interrelatedness of elements; and
- increase in number of combinations.

3.6 Implementation of data generating strategies

The strategies implemented to generate data with supporting evidence in the different levels of evaluation, as well as the order in which these were implemented, are indicated in figure

3.1. Each data generating strategy implemented for each level of learning will now be discussed according to the levels.

3.6.1 Level 1: Reaction

The way in which the two data generating strategies on level 1 were implemented during the research, namely the questionnaire and the semi-structured interviews will now be discussed.

3.6.1.1 The questionnaire

The flexibility of the research methodology allowed me to implement the questionnaire and the exercise simultaneously. Chronologically, the exercise was implemented before the questionnaire. The reason for this order was that the questionnaire was part of the paper copy of the exercise. Students were required to complete the questionnaire on paper immediately after completion of the tutorial and the exercise. It was necessary to determine the students' reaction directly after completion of the tutorial (Kirkpatrick, 1994).

Kirkpatrick (1994) listed a number of steps for evaluating reaction, which I adapted into a checklist, indicating the procedure followed in measuring the participants' reaction. I selected a number of Kirkpatrick's suggestions and applied these to the study. Table 3.8 indicates Kirkpatrick's (1994) suggestions that I selected as well as the rationale for choosing each item.

According to Kirkpatrick the first level is usually assessed through survey or questionnaire methodology (Kirkpatrick, 1994). For this study, I used two instruments to gather data at the reaction level, i.e. a questionnaire and a semi-structured interview.

Table 3.8 Checklist for procedure followed in measuring reaction

	Steps suggested by Kirkpatrick (1994)	Yes	No	Rationale for researcher's actions
1.	Determine what you want to say[6]	✔		Designed questions pertaining to affective reactions and to utility judgements (Alliger *et al.*, 1997)
2.	Design a form that will quantify reactions		✘	Designed a form allowing for qualitative responses for spontaneity and unbiased responses (Cohen *et al.*, 2000)

[6] I used the augmented framework (Alliger *et al.*, 1997) to design the questions for the questionnaire and semi-structured interview, as it discriminates between affective reactions and utility judgements. In this way I gathered more detailed information about the participants' likes and dislikes as it has evolved in evaluation practice (Bates, 2004).

	Steps suggested by Kirkpatrick (1994)	Yes	No	Rationale for researcher's actions
1.	Determine what you want to say[6]	✔		Designed questions pertaining to affective reactions and to utility judgements (Alliger *et al.*, 1997)
3.	Encourage written comments and suggestions	✔		Encouraged detail and specificity (Cohen *et al.*, 2000)
4.	Get 100 percent immediate response	✔		All 22 participants responded immediately after completing the tutorial (Kirkpatrick, 1994)
5.	Get honest responses	✔		Encouraged honesty (Cohen *et al.*, 2000)
6.	Develop acceptable standards	✔		Content analysis measured against recognised constructs to achieve objective interpretation of open-ended written responses (Cohen *et al.*, 2000)
7.	Measure reactions against standards, and take appropriate action	✔		A criterion-related coding systems was developed for setting standard and unbiased analysis of responses (Cohen *et al.*, 2000)
8.	Communicate reactions as appropriate	✔		Documented and analysed (Cohen *et al.*, 2000)

The questionnaire was conducted directly after the students had completed the tutorial and the exercise in their own time. It consisted of open-ended questions encouraging detail and not a "happy face" survey as suggested by Kirkpatrick (1994). I encouraged honest written comments.

3.6.1.2 The semi-structured interview

The semi-structured interview was conducted one week after the responses to the questionnaire had been studied closely. The aim of the interview was to add richness through probing and prompting enabling participants to elaborate, explain and clarify where necessary. After examination of the responses to the questionnaire, the sample of three participants was selected. I re-examined the responses of the three participants and then designed the basis for the semi-structured interviews (Addendum 3).

3.6.2 Level 2: Learning

Kirkpatrick listed a number of steps for evaluating learning, which I adapted into a checklist (table 3.10), indicating the procedure that was followed in assessing the participants' learning. I selected a number of Kirkpatrick's (1994) suggestions and applied these to the study. Table 3.9 indicates Kirkpatrick's (1994) suggestions that were selected and the rationale for choosing each item.

Table 3.9 Checklist for procedure followed in measuring learning

	Steps suggested by Kirkpatrick (1994)	Yes	No	Rationale for researcher's actions
1.	Use a control group if practical.		✘	Because of time constraints and the structure of the module, it was not practical to use a control group.
2.	Evaluate knowledge, skills, and/or attitudes both before and after the intervention. Use a paper-and pencil test to measure knowledge and attitudes, and use a performance test to measure skills.	✔		**Knowledge** of design theory was tested through a paper-and-pencil exercise in visual analysis immediately after the tutorial. This would indicate participants' immediate retention of knowledge. **Skills** Visual analysis skills were tested in a sequential test after a period of time. Revealing design knowledge through drawing skills was tested in the sequential test after a period of time. Attitudes were not measured as these were not relevant to this research.
3.	Get a 100 percent response.	✔		All three participants engaged in the evaluation.
4.	Use the results of the evaluation to take appropriate action.	✔		Results were used to determine the course of the rest of the module as well as of the remainder of the data generating strategies.

According to Kirkpatrick the second level is usually assessed through tests prior to/during the instruction (Kirkpatrick, 1994). For this study, I used two instruments to gather data at the learning level, i.e. an exercise and a sequential test.

3.6.2.1 The exercise

As was discussed previously, 22 of the initial number of students completed the exercise immediately after completing the tutorial. They were provided with paper copies of the exercise on which they had to complete their responses. In this way they could freely navigate between the slides on the tutorial, looking for information relevant to the questions.

3.6.2.2 The test

Two weeks after the interviews had been conducted, all students wrote a summative sequential test regarding, inter alia, the aesthetic design theory. At the time of the test, all students in the course had had the opportunity to work through the tutorial for the first time.

3.6.3 Level 3: Behaviour

Kirkpatrick (1994) listed a number of steps for evaluating behaviour, which I adapted into a checklist (table 3.10). Kirkpatrick's (1994) suggestions selected and applied to this study are indicated in table 3.10 that also indicates the rationale for each selected item.

Table 3.10 Checklist for procedure followed in measuring transfer/behaviour

	Steps	Yes	No	Rationale
1.	Use a control group if practical.		✗	Not practical.
2.	Allow time for changes in behaviour to take place.	✔		Project two months later and examination three months later.
3.	Evaluate before and after the programme if practical.		✗	Not practical.
4.	Survey and/or interview one or more of the following: trainees, their immediate supervisor, their subordinates, and others who often observe their behaviour.	✔		Interviewed the trainees. I was the trainer and only observer.
5.	Get 100 percent response or a sampling.	✔		
6.	Repeat the evaluation at appropriate times.	✔		Repeated during end-of-year examination.
7.	Consider cost versus benefits.			

Unlike the two levels discussed earlier, level 1: reaction, and level 2: learning, Alliger's (1997) augmented model of Kirkpatrick's (1994) four level model did not suggest a detailed way of measuring behaviour. I, therefore, followed Kirkpatrick's (1994) suggestions to:

- allow time for changes in behaviour to take place before assessing; and
- repeat the evaluation at an appropriate time (Kirkpatrick, 1994).

I assessed whether participants preserved the knowledge they demonstrated in level 2, namely whether they could transfer the learning to new situations during two separate assessment opportunities. The first opportunity was at the end of a project (two months after the intervention). The second assessment took place during an end-of-year examination (three months after the intervention).

3.6.3.1 The project

Due to the fact that the course was project-driven, students were introduced to the project at the outset of the module. At the same time they were required to engage in multiple tasks of which the following was the basis:

- researching the nature of the problem and investigating possible solutions (which is not relevant to this study);
- working through the tutorial in their own time;
- practicing drawing skills; and
- doing a variety of classroom-based perceptual and analytical tasks.

The projects were assessed on a continuous and formative basis. The students were required to exhibit their projects after completion, including the documented design process of which their representational drawings formed part.

3.6.3.2 End-of-year examination

The summative end-of-year examination was conducted one month after the final products were delivered and displayed in class. The examination was compulsory for all students in the module and took place under controlled examination conditions.

3.7 Capturing of data

The data informing the main research question and its sub-questions were captured in different forms and illustrated in figure 3.3, 3.4 and 3.5 respectively. Data captured for research question 1 were verbal. Participants responded to the questionnaire by providing their responses in writing. Their responses were later edited and made available electronically (Addendum 2). They also responded to the semi-structured interviews verbally by answering the interviewer's (my) questions. I made notes of the responses, edited and made these available electronically (Addendum 4).

Data for research question 2 were verbal and pictorial. Information gathered on sub-question 1 was captured through participants' responses to the exercise in their own words. They presented their visual analyses of the particular designs in writing. Responses to the sequential test were verbal, as participants were required to complete a visual analysis of existing designs. Responses were also pictorial as participants where required to present their understanding of the content of the tutorial in the form of free-hand drawings (schemas). These forms of data capturing are illustrated in figure 3.4. Data were captured in the form of qualitative descriptions, explanations and interpretations of participants' responses measuring these against the recognised domain specific constructs and criteria. These responses were later edited and also made available electronically (Addendum 6).

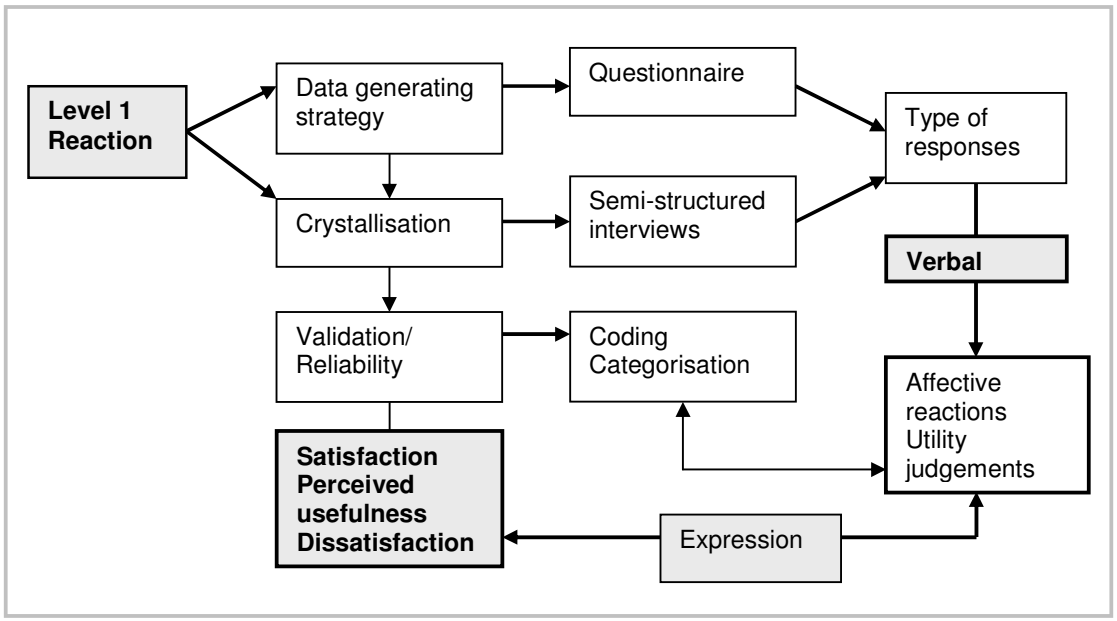

Figure 3.3 Data capturing for research question 1 (evaluating level 1 – reaction)

Data collected for answering the second sub-question, were gathered from a sequential test requiring participants to visualise their understanding of some design principles and design elements. The responses were captured in the form of schematised drawings reflecting participants' conceptual understanding of design principles, design elements and techniques used in the test some time after the tutorial. Figure 3.4 illustrates the data capturing process for establishing learning on level 2. This process was complicated due to the fact that two different types of activities were involved, which needed to be captured in two different ways, namely:

- written explanations, descriptions and analyses; and
- pictorial demonstrations of knowledge and understanding constructs.

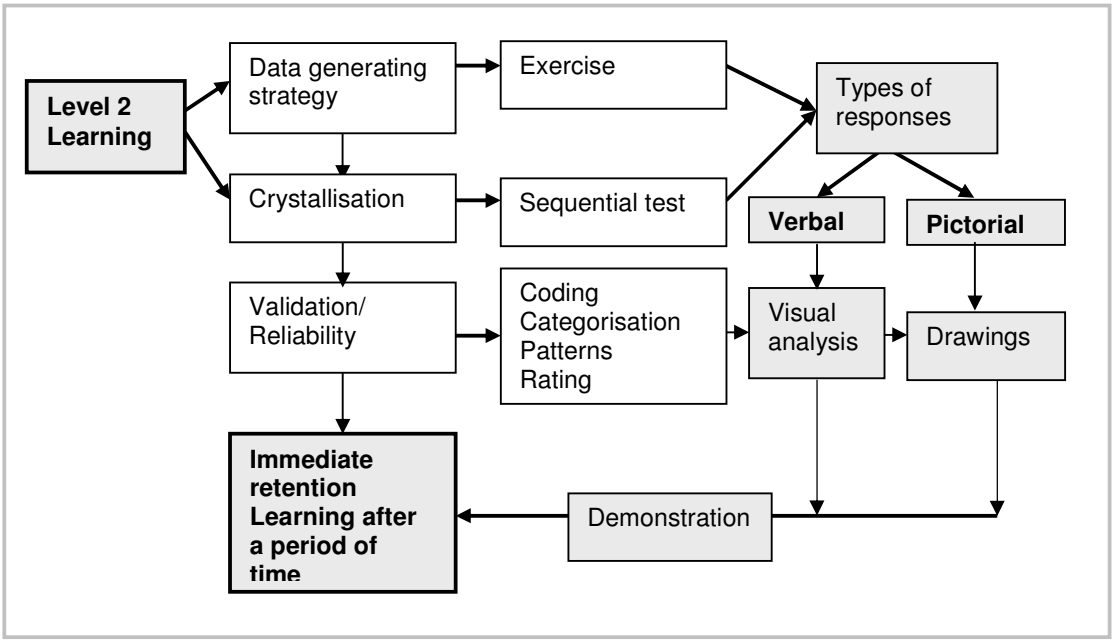

Figure 3.4 Data capturing for research question 2 (evaluating level 2 – learning)

In contrast to the process of gathering information for research question 2, data for research question 3 were less complicated as all participants' responses considered were only pictorial. Participants were required to present their understanding of the content of the tutorial in the form of free-hand drawings of their own designs (figure 3.5).

The responses were captured in the form of representational drawings in the project and exploratory drawings in the examination that reflected participants' conceptual understanding of design principles, design elements and techniques used in the test some time after the tutorial.

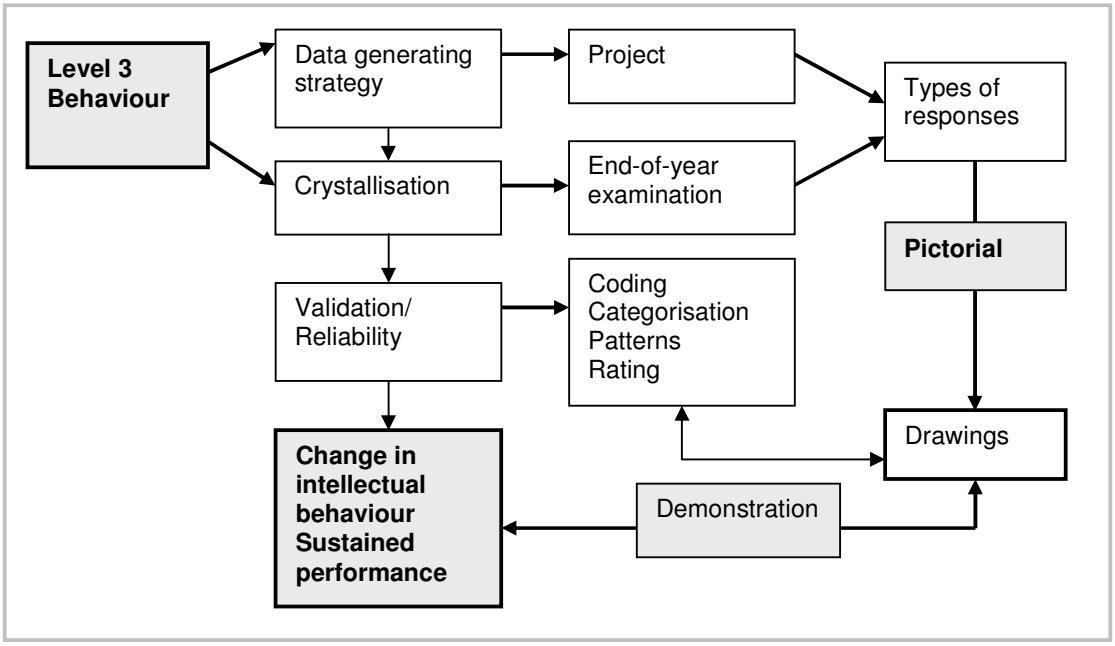

Figure 3.5 Data capturing for research question 3 (evaluating level 3 – behaviour)

3.8 Data analysis

After the data capturing and editing process, the data were analysed. I was the expert in the domain involved and was the only party involved in the instruction and intervention with the tutorial. As such, inter-validity was achieved. Interpretive validity was achieved through multiple readings of responses to the questionnaire and documentation of the interviews. External validity was achieved in two ways. Firstly, measuring domain-related responses ensured construct validity and interpretations to a classic work in the domain of design. Secondly, setting standards and relating them to a rating system in order to establish the sample's performance achieved criterion-related validity. Crystallisation was achieved through applying multiple research instruments (Cohen *et al.*, 2000). Table 3.11 summarises the data generating strategies that were implemented in the levels of evaluation under discussion.

Table 3.11 Data generating strategies implemented in the levels of evaluation of the tutorial

	Research question 1 Level 1 Reaction	**Research question 2 Level 2 Learning**	**Research question 3 Level 3 Behaviour**
Instruments	Questionnaire	Exercise	Projects
Crystallisation	Semi-structured interviews	Sequential test	End-of-year examination
Validity and reliability	Categorisation Coding	Criterion-based Categorisation Patterns Coding Rating	Criterion-based Categorisation Patterns Coding Rating
Interpretation	Qualitative	Qualitative and Quantitative	Qualitative and Quantitative

The procedures involved in the analysis of the data for level 1, will subsequently be discussed.

3.8.1 Level 1: Reaction

At the first level, i.e. reaction, I assessed participants' initial reactions to the tutorial. It offered insight into participants' satisfaction, dissatisfaction with certain aspects of the tutorial and its perceived usefulness. Although measuring reaction is not an indication of learning taking place (Kirkpatrick, 1994), a positive reaction to the tutorial would indicate that the participants were motivated to interact with the tutorial. Table 4.2 indicates the questions eliciting the three categories of responses:

- general satisfaction;
- dissatisfaction; and
- perceived usefulness.

Data analysis in the two data generating instruments on level 1, the questionnaire and the interview, will now be discussed.

3.8.1.1 The questionnaire

The content of the responses to the questionnaire and semi-structured interviews were analysed by careful reading and re-reading against the recognised domain-specific constructs built into the tutorial. In order to establish reliability and validity in the analysis process a criterion-related coding systems was developed for setting standard and unbiased analysis of responses (Cohen et al., 2000, p.284). I created codes for analysing and categorising the comments into two types of reactions – affective reactions and utility judgements (table 3.13). Affective reaction was then categorised in two sub-groups, based on the coding system created, namely:

- general satisfaction; and
- dissatisfaction.

The affective comments were selected by looking for words and phrases including or implying "I like …", "I did not like …" "I would like ... to be different". The phrases were read and carefully re-read, in order to ensure validity. The comments were classified into three groups; (1) those indicating general satisfaction, (2) those indicating perceived usefulness and (3) those indicating dissatisfaction.

In the case of participants' utility judgements in the questionnaire and interview, the procedure was as follows: at first two categories of comments were created:

- comments pertaining to the relevance of the tutorial and to the potential for application; and
- comments pertaining to what participants thought they learnt through the tutorial.

I analysed the content in order to make meaning of the responses. I wanted to judge whether participants thought that working through the tutorial was time well spent. This judgement had to be viewed in the context of how long it took participants to complete the tutorial, determined by participants through question 11 of the questionnaire (Addendum 1) and additional information gained through the interviews (Addendum 3).

3.8.1.2 The semi-structured interviews

Content analysis was selected as the method of data analysis for the interview. Since the same classes of questions were used in the questionnaire and the interviews, I used the same categorising and coding system followed in the analysis of the responses to the questionnaire to analyse the data generated through the interview (see table 3.12).

Table 3.12 Coding system for analysing reaction, content of questionnaire and semi-structured interview

Categories	Coding
General satisfaction	Words: "like", "enjoyed", "easy", "very much", "comfortable", "understand", "user-friendly", "well-organised", "comprehensive", "straightforward"
Perceived usefulness	Phrases: "a positive indication that learning of a particular domain-specific construct was learned" Phrases: "a positive indication that no construct was less well understood than any other" Words/phrases referring to relevance of the content to other modules
Dissatisfaction	Direct statements: "too little", "too long", "could not understand", "not useful", "did not like" Negative words: "unorganised", 'unclear", "confusing" indirect statements: "would like … different", "would like to ..."

Figure 3.6 illustrates the integration network for the data analysis process involved in level 1.

3.8.2 Level 2: Learning

Kirkpatrick maintains that it is not only the measured increase in knowledge that is important to the researcher for indicating the effectiveness of the training, but also the specific information that evaluation of learning provides (Kirkpatrick, 1994). For this reason I selected a method of analysing and describing the participants' specific knowledge and skills that would indicate the participants' knowledge and understanding of constructs of the design theory as confirmed by experts and classic works on aesthetic design theory (Lauer, 1985; Wong, 1993).

Evaluating the research data for level 2 involved analysing two types of data, namely visual analyses and drawings. These types of data were generated by the following strategies:

- the exercise, evaluating immediate retention provided visual analyses; and
- the sequential test provided visual analyses as well as drawings.

Data captured in the exercise and in the sequential test, were analysed by categorising it. The knowledge demonstrated in the exercise was categorised as immediate retention and the knowledge demonstrated in the test was categorised as knowledge after a period of time. The knowledge was then further categorised in two groups of cognitive activities. The first belonged to the group of visual analysis and the second belonged to the group of visualising knowledge through drawings. In each category the domain-specific constructs covered by the content of the tutorial served as coding system for evaluating knowledge at this level. Figure 3.7 illustrates the categorisation and coding system used for evaluating level 2.

The way in which each type of data in the two activities, drawing and visual analysis, was analysed, will subsequently be described.

3.8.2.1 Drawing

In order to assess the way in which their drawings revealed their cognitive thought as manifested in the sequential test, I used Tversky's theory that all drawings can be broken down in elements or segments (Tversky, 1999). She maintains that all drawings reveal elements or segments of construction or thought in a particular domain and that a small number of segments or elements are used in varying combinations to produce a potentially infinite set of drawings. These segments are:

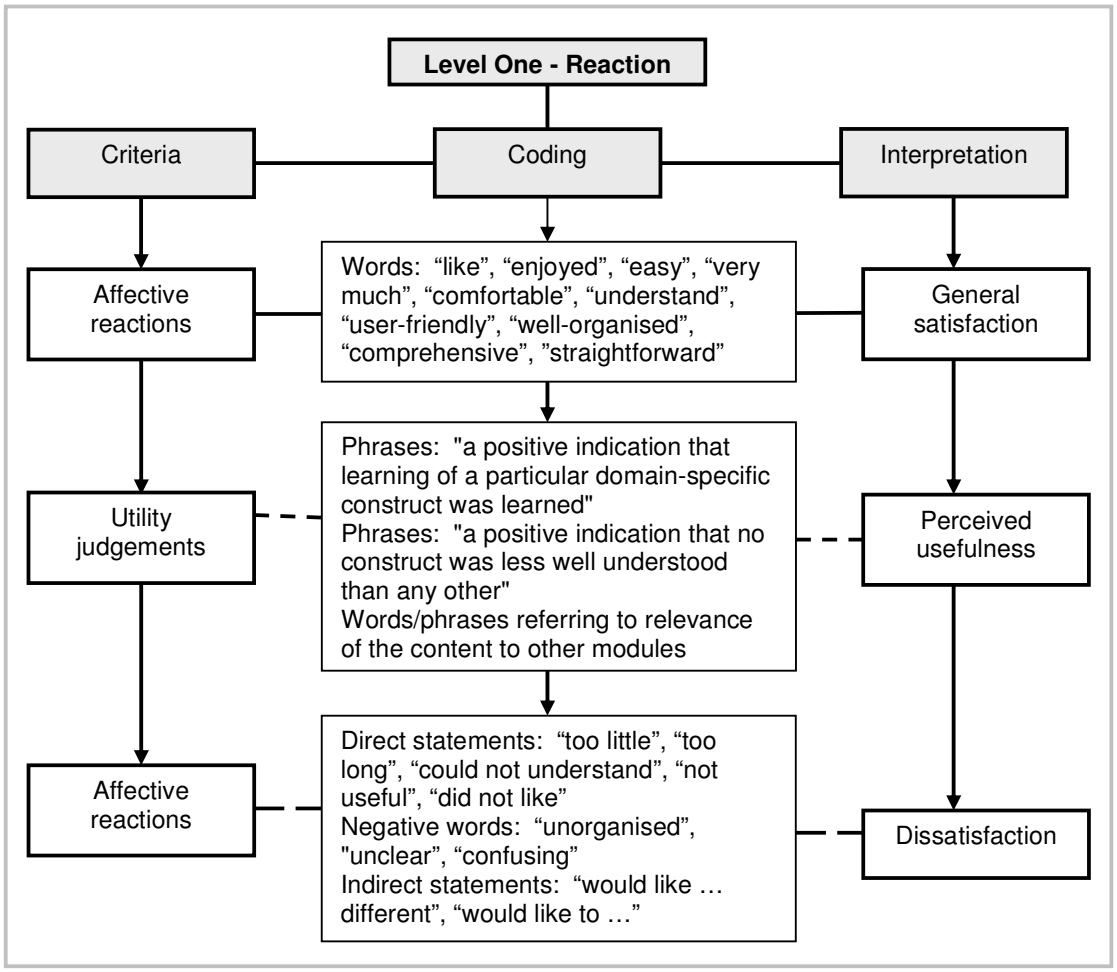

Figure 3.6 Analysing data for Research Question 1 (evaluating Level 1 – Reaction)

- appropriate to the particular domain, reflecting the underlying conceptual structure of that domain;
- units of drawings;
- schematised to reflect general, summary properties of the entities they convey, without detail or analogue properties; and that
- as designing progresses design elements take a more specific form and are the schematisation of elements sharpened and refined.

I applied this theory to analyse participants' drawings as it allowed me to obtain insight into what conceptual modules were operative in a participant and how these were schematised. Research has shown that drawings should, inter alia, be seen as

- clues to mental conceptualisations of the domain;

- revelations of participants' conception of things – not their perception of things;
- more than perceptions of things/images;
- representations of reality and not presentations of reality; and
- naturally segmented into elements that can be schematised and spatially arranged in endless ways (Tversky, 1999).

Table 3.13 Coding system for analysing learning after a period of time in questions relating to drawing

Activity	Criterion	Construct	Coding	Cognitive indicator
Drawing	Retention after a period of time	Design principles	unity, balance, scale, proportion, emphasis, rhythm, illusion of space	• Realisation of design principles • Number of techniques used • Number of design elements used • Way in which design elements were arranged on the format
		Design elements	line, shape, size, texture, illusion of movement, colour, tonal value	
		Design techniques	repetition, addition, omission, distortion, enlargement, diminution	

Objective and valid measuring of participants' learning was a complicated and time-consuming task. The design of a scoring system for this summative test was done on the following basis.

Measurement of learning in this study proved to be more difficult and time consuming than the measurement of reactions, which is confirmed by Kirkpatrick (1994) The reasons for this are closely linked to:

- the complexity of the criterion set for the activities of visual analysis and drawing; and
- the compound way in which constructs appropriate to the domain can manifest in designs (Tversky, 1999), which is explained in section 4.7.3.

3.8.2.2 Visual analysis

In order to ensure validity and reliability, I created a coding system for evaluating the drawings in the test (table 3.14). This system is indicated in table 3.15 and its integration in the analysis process is illustrated in figure 3.7.

A coding system was designed in order to ensure validity of the analysis and interpretation of participants' responses to the visual analysis exercise establishing the knowledge retained immediately after the tutorial. The same coding system was used for analysing and interpreting participants' responses to question 5 of the test (also requiring participants to do a visual analysis of designs). Words, phrases and definitions indicating a conceptual

understanding of the different design principles and design elements, including the use of the correct terminology used in the tutorial, were considered as a demonstration of knowledge retention. The terminology I looked for is summarised in table 3.14. In order to measure understanding, I looked for cognitive indicators such as descriptions and explanations of the relationships between techniques used and the visual effect achieved. Figure 3.7 illustrates the integration network for the data analysis process involved in the analysis of data on level 2.

The questions in the test under discussion were completely open-ended and non-directed. Students were given three images of designs to be analysed and discussed without directing them in any way towards specific constructs in operation. This was a difficulty in the research as there were numerous possible combinations and relationships (Tversky, 1999) that could not all be foreseen and were established in the reading and re-reading process. If a student was able to identify only the principles without recognising the elements and techniques applied, it was considered a demonstration of poor application of analytical skills. The more design principles the participant could identify and elements and techniques recognised, the better the skills were regarded to be. Triangulation was found if the responses contained the correct terminology, the preciseness and detailed specificity of the descriptions and the ability to explain the effect the specific constructs in a particular design had on each other.

Table 3.14 Coding system for analysing immediate retention in the questions relating to visual analysis

Activity	Criterion	Construct	Coding	Cognitive indicator
Visual analysis	Immediate retention and retention after a	Design principles	unity, balance, scale, proportion, emphasis, rhythm, illusion of space	• Definitions • Explanations • Descriptions • Relations drawn
		Design elements	line, shape, size, texture, illusion of movement, colour, tonal value	
		Design techniques	repetition, addition, omission, distortion, enlargement, diminution	

In order to ensure validity of the analysis and interpretation of participants' responses to the visual analysis exercise establishing the knowledge retained immediately after the tutorial, a coding system was designed. The same coding system was used for analysing and interpreting participants' responses to question 5 of the sequential test (also requiring them to do visual analysis of designs). Words, phrases and definitions indicating a conceptual

understanding of the different design principles and design elements, including the use of the correct terminology that was used in the tutorial, were considered as a demonstration of knowledge retention. The terminology I looked for is summarised in table 4.6. In order to establish understanding, I looked for cognitive indicators such as descriptions and explanations of the relationships between the techniques used and the visual effect achieved.

A separate coding system was designed for analysing and interpreting participants' drawings in the test. Considering the fact that researchers in the field of visual literacy regard drawings as a cognitive tool that can reveal thought and conceptual understanding (Tversky, 1999), a coding system was created as a standard for measuring the quality of participants' understanding of the constructs under discussion. Table 3.15 summarises the system applied.

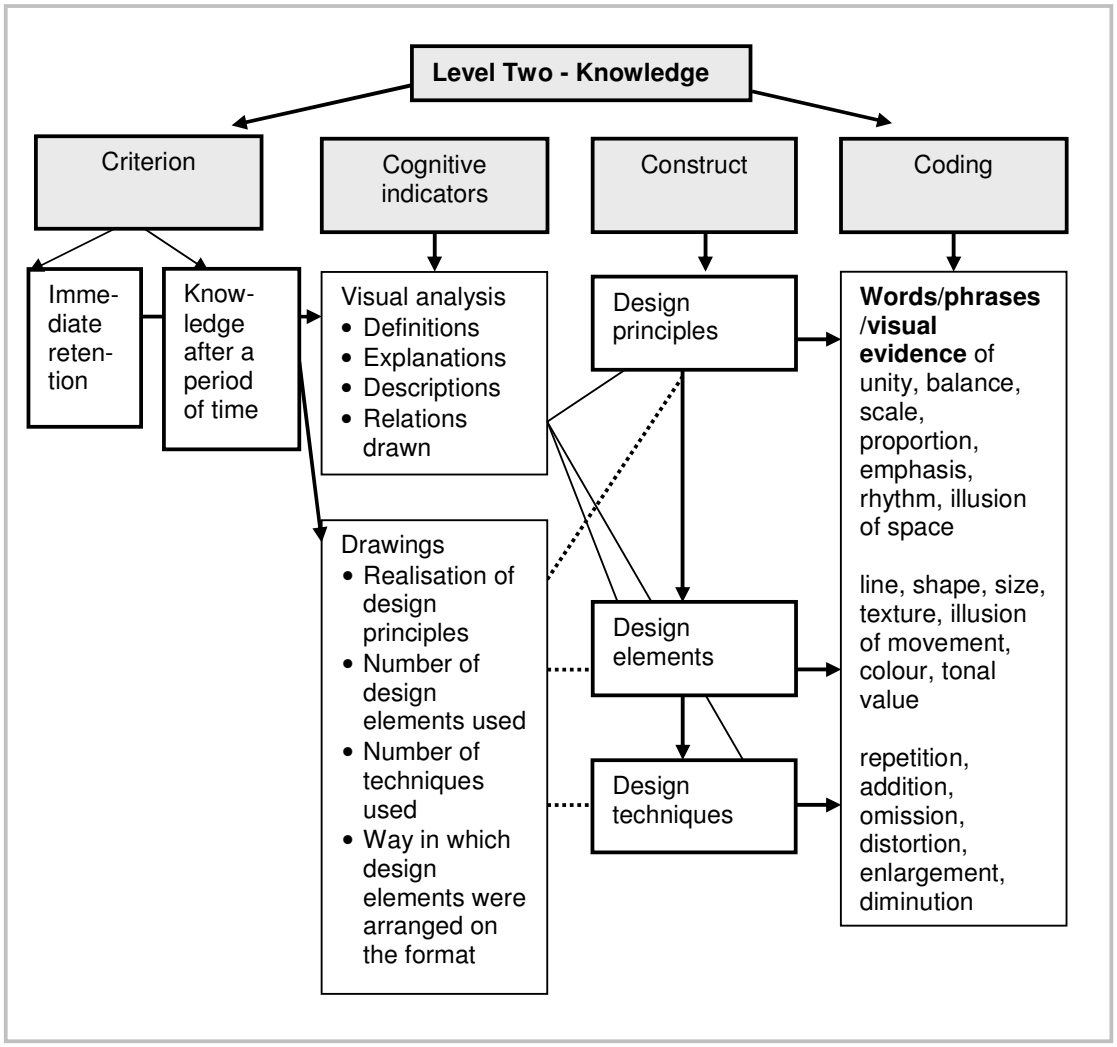

Figure 3.7 Analysing data for research question 2 (evaluating level 2 – knowledge)

3.8.3 Level 3: Behaviour

For analysing the pictorial data generated on level 3, in the project as well as the examination, I used the same procedure and system for coding and decoding as for the drawings assessed on level 2 and generated by the test (see section 3.8.2.1, table 3.14). Figure 3.8 illustrates the integration network involved in the analysis of data analysis on level 3.

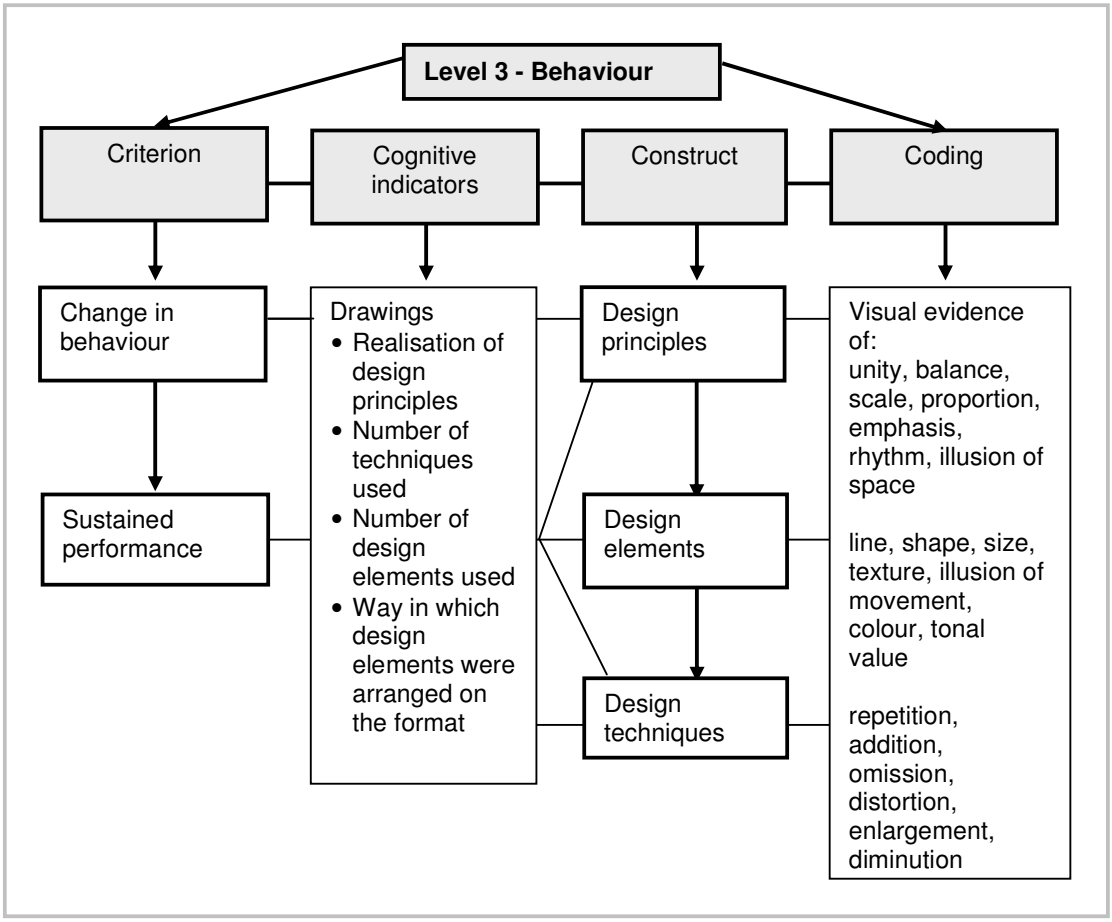

Figure 3.8 Analysing data for research question 3 (evaluating level 3– behaviour)

In the following section I will summarise the way in which I ensured validity and reliability for this study.

3.9 Validity and reliability

Ensuring validity and reliability was closely connected to the approach of this study, namely development research, as well as to that of the qualitative nature of data and the interpretation thereof (figure 3.2). All the measures taken to ensure validity and reliability, therefore, have to be viewed against this background. Internal validity was achieved through accurate descriptions of findings.

External validity was achieved through detailed and in-depth descriptions creating thickness and richness. I achieved construct validity by categorising data and using domain-specific constructs derived from classic works in the domain of aesthetic design theory. In order to achieve criterion-related validity Kirkpatrick's model for evaluating four levels of learning (Kirkpatrick, 1994), in combination with Alliger's augmented model refining Kirkpatrick's model (Alliger *et al.*, 1997), was used to categorise the levels of learning (figure 3.1). Crystallisation of findings was achieved by using multiple data generating strategies and instruments on each level of learning as illustrated in figure 3.1.

3.10 Limitations of the methodology followed in this study

Limitations of the study were inherent to the development approach to this research:

- The research focused on limited examples in the intervention only, namely the assessment opportunities, and did not take other examples of learning e.g. class discussions and group work, into account.
- Providing for rigor and control in the research methodology was time consuming due to the multiple data generating strategies needed to ensure validity and reliability.
- I was at the same time developer of the intervention (the tutorial), the lecturer of the module as well as the researcher, which had inherent limitations of subjectivity.

Limitations inherent to the qualitative nature of the data and interpretation, therefore, were experienced in the following:

- I experienced the creation of coherence in reporting the findings difficult due to the complexity of the module and its multi-faceted learning outcomes.
- It was difficult defining concepts that have various meanings across different related disciplines, e.g. "design", "technology", "design process", etc., which led to over-explanation.

It was difficult to work according to the structure provided by Kirkpatrick's (1994) model while much information was emerging from the findings that needed to be explained in a causal way, not allowed for by Kirkpatrick's (1994) four levels.

Population and sampling methods in this study posed their own limitations.

- The sampling method implemented, namely convenience sampling, did not allow for generalisation of the findings, as it did not attempt to represent the group.
- The sample was very small, namely three participants, which also minimized generalisation.

Data collecting strategies were time consuming. Due to the nature of Kirkpatrick's (1994) model, the data had to be collected over a relatively long period of time, and could not be concluded after the completion of one strategy. Implementing sufficient strategies and instruments took three months to conclude. Data analysis and, therefore, validity and reliability, were subjected to the following limitations. Analysing responses to the questionnaire revealed the following:

- Not all participants understood questions in the same way and needed clarification during the interviews.
- The open-endedness of the questions elicited a multitude of answers, which were time consuming to categorise and decode.

The variety of responses to the different data gathering strategies posed many questions that could be answered within Kirkpatrick's (1994) model. These questions will be discussed in chapter 5.

In spite of pre-selecting and structuring the questions in the same way as those in the questionnaire, the semi-structured interviews elicited extra information that was subjected to poor prompting and probing due to my inexperience as interviewer.

The data generated during the other strategies, the exercise, the sequential test, the project and the end-of-year examination were, for the purpose of this discussion, all classified as "tests" (Cohen *et al.*, 2000), because these were all evaluated as summative assessment opportunities. As such, creating a comprehensive coding system, and establishing an efficient system for assessing reliable cognitive indicators posed its own difficulties and limitations. It was time consuming and labour intensive to ensure that under-representation of constructs did not occur, but that there was an overall fair representation of all the constructs I wanted to test.

Analysing the data had its own set of limitations inherent to the nature of the data and the context of the research. Due to the fact that I was the only party involved in the research, I had to rely on my credibility and analytical abilities as sole analiser and interpreter of the data (Hoepfl, 1997). In addition, the fact that two types of activities, namely visual analysis and drawing, were required of participants in all assessment opportunities, I experienced the following as limiting:

- Poor language and writing skills could negatively affect individual participant's performance or demonstration of learning.
- Poor drawing skills could negatively influence participants' visual revealing of constructs.

- Crystallisation methods, through multiple analyses were time consuming and labour intensive.

Kirkpatrick's model for evaluation of learning (Kirkpatrick, 1994) posed its own set of limitations on this research in general:

- Although a practical tool for evaluating learning in a systematic way, it oversimplified the evaluation process, which had to be refined by combining it with Alliger's augmented model (Alliger *et al.*, 1997). The study did not take into account the wide range of factors that could influence instruction, making generalisation difficult as the integration of the tutorial in the module relied heavily on the way it was integrated by the lecturer.
- The study could not indicate a causal chain between the different levels of learning (although Kirkpatrick's module assumes such a link) (Kirkpatrick, 1994).
- Little evidence of substantial correlation between the findings on the different levels. Participant 14, for example, seemed to have a positive reaction (level 1) towards the intervention, performed fairly well on level 2 (learning), but did not perform well in transfer of knowledge on level 3 (behaviour).

In chapter 4 I will report on the findings of the research in order to answer the three research questions. It will be shown that the structured order of the module JOT120 under discussion the different activities including how the intervention contributed to varying degrees of students' development of: identifying and solving authentic product design problems by:

- implementing the design process;
- exploring more than one possible solution;
- exploring more than one way to arrive at a good solution;
- acknowledging the complexity of design problems;
- considering the four design aspects: functionality, aesthetics, ergonomics and value;
- combining thinking and doing by linking abstract concepts to concrete understanding;
- carrying out practical projects using a variety of technological skills;
- solving problems through a process of investigating, designing, making, evaluating, communicating that suits different learning styles; and
- using and engaging with knowledge in a purposeful way (University of Pretoria, 2003).

In this chapter I have described the research approach and the model for evaluating levels of learning. I have also discussed the strategies implemented for gathering information and the

way in which it was analysed. In the following chapter I will report on the findings of this study.

4.1 Introduction

The reason for evaluating instruction programmes is to determine their effectiveness. To evaluate such effectiveness implies that the instructor/educator should have clear objectives for the different aspects of the programme within a pre-determined subject content or domain (Kirkpatrick, 1994). The four levels in Kirkpatrick's model (figure 2.1) represent a sequence of methods for evaluating instructional programmes. Each level builds on the previous one, implying a hierarchical order in which to execute the evaluation, with the process becoming more difficult and time consuming to perform at each higher level, but also providing more valuable information (Kirkpatrick, 1994). In this study information was sought regarding the learning of constructs specific to the domain of aesthetics, namely design principles, elements and techniques (Tversky, 1999).

In this study I examined the effectiveness of an electronic tutorial within a design and technology programme of which the objectives were twofold:

1. to gain knowledge and skills:
    - differentiate between the constructs of design principles, elements and techniques;
    - identify the above concepts in a given design through visual analysis; and
    - visualise the above concepts through free hand drawings.
2. to change behaviour through sustained performance:
    - demonstrate the conceptual understanding of the constructs of design principles, elements and techniques by applying it in new designs of their own.

The main research question to be answered is:

What was the role of the tutorial, *Design in Action* (a computer-aided tool), in Kirkpatrick's three levels of learning in a first year design and technology education programme?

Three research questions were derived from this question (see chapter 3). The first question will now be addressed**.**

4.2 Research question 1: What are the implications of the participants' reaction to the tutorial with regard to the possible improvement thereof?

Sub-question 1: Were the participants satisfied/dissatisfied with the tutorial?

Sub-question 2: What was the perceived usefulness of the tutorial?

Sub-question 3: What in the tutorial were the participants dissatisfied with?

In the following sections the levels will be discussed at which learning took place as a result of integrating the tutorial as a building block in the understanding and using of the design knowledge of three participants.

4.2.1 Data collection for research question 1

The different activities in the module under discussion were focused on the understanding of formal aesthetic design constructs that are appropriate to the domain in a design and technology education context by applying formal design theory and visualisation skills during a project. It will be shown how intervention in the module with *Design in Action*, an electronic tutorial in Microsoft PowerPoint™, contributed to participants' different levels of learning. The first level, i.e. reaction, at which learning took place as a result of integrating the tutorial, will be discussed.

4.2.2 Level 1: Reaction

According to Kirkpatrick, the word *reaction* implies that evaluation on this level measures how those who participate in the training react to it. He says:

> *Evaluating reaction is the same thing as measuring customer satisfaction. If training is going to be effective it is important that trainees react favourably to it. Otherwise, they will not be motivated to learn* (Kirkpatrick, 1994 p.27).

Kirkpatrick (1994) is further of the opinion that learners' reaction is an indication of their motivation and that, although a positive reaction does not guarantee learning, a negative reaction almost certainly reduces its possibility. He maintains that the future of a programme depends on positive reaction. It is important not only to get a reaction, but also to get a positive reaction.

At the first level, i.e. reaction, I assessed participants' initial reactions to the tutorial. It offered insight into participants' satisfaction or dissatisfaction with certain aspects of the tutorial and the perceived usefulness of the tutorial. Although measuring reaction is not an indication of the learning that takes place (Kirkpatrick, 1994), a positive reaction to the tutorial would indicate that the participants were motivated to interact with the tutorial. Table 4.2 indicates the questions eliciting the three categories of responses:

- general satisfaction;
- dissatisfaction; and
- perceived usefulness.

4.2.3 Discussion

In the discussion that follows, I will analyse and discuss three praticipants' responses to the questionnaire. I will analyse and discuss what the general satisfaction, dissatisfaction and perceived usefulness of the tutorial were. From the data presented, research question 1, "What are the implications of the participants' reaction to the tutorial with regard to the possible improvement thereof?" will now be answered. (See table 3.13 in chapter 3 for the coding system used to analyse reaction).

4.2.3.1 Sub-question 1: Were the participants satisfied/dissatisfied with the tutorial?

In this section, the affective reactions of the three participants will be presented. Evidence from the questionnaire and semi-structured interviews are drawn upon to support the discussion (addendum 2). It will be argued that their general satisfaction contributed to their motivation to use the tutorial and have a positive influence on their future application and transfer of the content of the tutorial.

The questions in the questionnaire used to gather information about the general satisfaction with the tutorial through affective responses, were the following:

- Question 1: "What did you like most about the tutorial?"
- Question 4: "Could you understand the language and the terminology used in the tutorial?"

From their responses it was apparent that participants found the tutorial easy to work with, that they were comfortable working with it, found the examples pleasing and experienced the tutorial as accessible:

- *It is easy to work with and you can work at your own pace*[7] (participant 9).
- *It was very user-friendly, there was nothing strange to the program… everyone who had CIL in the first year, ought to know how to work the program* [8] (participant 14).
- *It was easily accessible and easy to work with* (participant 21).

There was some satisfaction with the comprehensiveness and organisation of the tutorial:

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[7] *"Dit was maklik om daarmee te werk en ek kon dit op my eie tyd doen"* (participant 9).

[8] *"Dit was baie 'user-friendly', daar is niks rêrig snaaks aan die program nie … almal wat CIL gehad het in die 1ste jaar hoort te weet hoe om die program te werk"* (participant 14).

> *I won't change anything. It is very comprehensive and well organised*[9] (participant 14).

The participants also liked the choice of examples as well as the layout in the tutorial:

- *I liked the colour examples very much. It was comfortable to use and everything was well organised*[10] (participant 9).
- *For me the layout of the program was the best, anybody could understand it. It was also interesting to see what people use to design*[11] (participant 14).
- *I liked the graphics. The colour and quality is really good* (participant 21).

It became clear that participants did not only like the examples used for the sake of its appearance, but also realised the educational value thereof:

> *I understand now that there are many different ways of achieving the same principle. Maybe if you could add more examples to show the different ways of reaching the same principle. The graphics make it much easier to remember and apply* (participant 21).

Participants found the language and terminology used in the tutorial clear, unambiguous and accessible. There was also a suggestion that even more illustrating examples be added to the tutorial:

> *Yes, very straightforward and easily understood. Maybe a little more pictures to show…* (participant 21).

The questionnaire and semi-structured interviews indicated that the participants were generally satisfied with the tutorial's organisation and visual appeal. The aspects participants liked and enjoyed most were:

- easy to use;
- easy to access;
- easy to understand the text; and
- visual appeal.

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[9] *"Ek sal niks verander nie. Dit is baie volledig en goed georganiseer"* (participant 14).
[10] *"Ek het baie van die kleur voorbeelde gehou. Dit was baie gerieflik om te gebruik en alles was mooi uiteengesit"* (participant 9).
[11] *"Vir my was die uitleg van die program die beste, enige iemand sal dit kan verstaan. Dit was ook vir my interessant om te sien wat mense gebruik om te design"* (participant 14).

The conclusion of sub-question 1 is, therefore, that the simplicity of the tutorial contributed to its ease of use and participants' general satisfaction with the intervention. Literature indicates that compliance to the above aspects would eliminate confusion and cognitive overload with the participants. Various references can be detected relating to learners' access to content and the fact that a user interface of the computer-aided material should facilitate access to the content (Atkinson, 1998; Recker, 1995).

The findings further indicated that the linearity of the tutorial contributed to its ease of use and, therefore, participants' general satisfaction. Research has shown that some learners find non-linear organisation confusing and opaque, contributing to cognitive overload for the user (Atkinson, 1998), and that hierarchical and linear organisation ensures transparency and easy access.

In addition, it was concluded that the visual appeal of the tutorial contributed to participants' enjoyment levels and motivational levels, which is confirmed by researchers in the field (Hannafin & Peck, 1988; Kirkpatrick, 1994). Considering all the findings of sub-question 1, there was sufficient evidence to conclude that participants were in general satisfied with the tutorial.

4.2.3.2 Sub-question 2: What was the perceived usefulness of the tutorial?

The term "perceived usefulness" is described as trainees' belief about the value and usefulness of the training; the extent to which they believe they will use the training on the job (Alliger *et al.*, 1997). In this study, it refers to the extent to which participants believed that they could apply the knowledge and believed that they would use the knowledge in other design related modules. (See table 3.13 in chapter 3 for the coding system used to analyse reaction.)

Establishing participants' perceived usefulness of the tutorial was mainly elicited from their utility judgements made in response to the following questions:

- Question 5: Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design?
- Question 9: Which aspect of the design theory in the tutorial did you understand the least?
- Question 11: Did you manage to complete the exercise in time?
- Question 12: Which aspect of design theory did you learn most about through the use of the tutorial?

Not all participants had a clear idea of which aspect of the tutorial content was least useful, i.e. which they had learned least about: *Nothing*[12] (participant 9). There was also some indication that all aspects were equally well explained. *Everything*[13] (participant 14). However, it became clear that the constructs “design principles" and "design elements" were better understood than isolated principles and elements*: The design elements and principles. Useful* (participant 21). Some participants thought that the principles "balance" and "illusion of motion" were understood better after exposure to the tutorial than any others. *Balance and illusion of motion*[14] (participant 9).

However, certain principles and elements were less well understood than others, e.g. the element "rhythm" and the principle "unity":

- *Everything was understandable. I understood everything equally well. Maybe just rhythm not*[15] (participant 9).
- *Unity and how to achieve it in a design* (participant 21).

A better understanding of the particular design elements developed gradually:

> *At the beginning I did not understand the elements. It was only later on in the tutorial that I started realising what was going on in the slides on unity. Now I understand it better* (participant 21).

During the semi-structured interviews, it became evident that by working through the tutorial, participants realised that the visual examples could also help them in one of the other modules in the design and technology programme earlier in the year:

- *Yes – because it’s easier to understand visual information*[16] (participant 9).
- *… it would have made things much clearer*[17] (participant 9).
- *Yes, I think it would have helped me with my designs. I believe everybody would have performed better*[18] (participant 14).

Useful suggestions for improving the module by introducing the tutorial earlier in the design and technology programme were evident from the semi-structured interviews:

> *Yes, maybe a lesson concentrating on this. Maybe also not on own time but during class time* (participant 21).

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[12] *“Niks”* (participant 9).
[13] *“Alles”* (participant 14).
[14] *“Balans en 'illusion of motion' ”* (participant 9).
[15] *“Dit was alles verstaanbaar, ek het alles ewe goed verstaan. Miskien net ritme nie”* (participant 9).
[16] *“Ja – want dit is makliker om visuele inligting te verstaan”* (participant 9).
[17] *“Ja, dit sou dinge baie duideliker gemaak het”* (participant 9).
[18] “Ja, ek dink dit sou my baie gehelp het met my ontwerpe. Ek glo almal sou beter gedoen het” (participant 14).

Those aspects participants indicated as the ones they had learned most about indicated that they considered the tutorial useful in supporting them to learn about certain design aspects. I learned from the responses to the questionnaire and semi-structured interviews that participants perceived the tutorial as useful, and, therefore, considered their time well spent because of the tutorials:

- relevance to the module;
- usefulness to other modules; and
- practical applicability.

4.2.3.3 Sub-question 3: About what in the tutorial were the participants dissatisfied?

There were two questions in the questionnaire that elicited information from affective comments by the participants (addendum 2):

- Question 2: "What would you have liked different in the tutorial?"
- Question 3: "What did you like least about the tutorial?"

It was evident from the responses to the questionnaire that some participants thought that the illustrative examples in the tutorial were too small and in response to question 2, participant 9 suggested that the pictures in the tutorial be larger: *… the pictures to be enlarged*[19].

Another suggestion for improvement of the tutorial was expressed in the dissatisfaction emerging from responses to question 2. Some participants were dissatisfied with the tutorial's lack of help. The responses suggested the inclusion of more navigational buttons, improving participants' sense of where they were in the tutorial:

> *I didn't like it at all to jump from one slide to another. It would really help if there were a way to know where to look for the answers in the exercise*[20].

Participants were irritated by the fact that the tutorial took very long to open from the Internet, as well as the time it took for some of the links from the tutorial to the Internet. In response to question 3, they wrote:

- *It is too slow to open from the site*[21] (participant 14).
- *The Internet links take a while to open. I don't know if you could do*

[19] *"Vir die prente om groter te wees"* (participant 9).
[20] "*Ek het niks daarvan gehou om heen en weer rond te spring van een 'slide' na die ander nie. Dit sal rêrig help as daar 'n manier is om te weet waar om na die antwoorde te soek in die oefening"* (participant 9).
[21] *"Dit is te stadig om van die 'site' oop te maak"* (participant 14).

something about that?[22] (participant 9).

- *The Internet links take a while to open*[23] (participant 14).

Some participants indicated that the language and terminology used in the tutorial was not always clear. *Not clearly* [24] (participant 9). However, it later emerged from the semi-structured interviews that the constructs were not clearly understood (contrary to what participant 21 said earlier), rather than specific terms, due to unclear titling of the design principles and design elements on each slide in the tutorial:

> *Some of the terminology was not clear. I think I was not always certain whether I was busy with principles and when with elements. Maybe it should be made clearer. Maybe clearer sections or something*[25] (participant 9).

During the interviews it became evident that participants took up to four hours and more to complete the tutorial and all the exercises. It became clear that they worked through the whole tutorial in one session, despite the fact that it was time consuming. They responded to question 11 in the following way:

- *Yes, it took approximately 4 hours' hard work*[26] (participant 14).
- *I completed all of them in my own time, but was time consuming, maybe should have been fewer designs to explain* (participant 21).

During the interviews, it was evident, however, that participants confused "own time" with "own pace":

> *I did work in the time you reserved the laboratory for us. I actually mean I worked at my own pace. There was nobody telling us how far we should be. I just carried on until I was finished with everything*[27] *(*participant 14).

Despite the fact that the laboratory was reserved for four hours, some participants did not manage to complete all the exercises:

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[22] *"Die Internet 'links' vat 'n rukkie om oop te maak. Ek weet nie of mevrou iets daaraan kan doen nie?"* (participant 9).
[23] *"Die internet 'links' vat 'n rukkie om oop te maak"* (participant 14).
[24] *"Nie duidelik nie"* (participant 9).
[25] *"Van die terminologie was nie duidelik nie. Ek dink ek was nie altyd seker of ek besig was met 'principles' en wanneer met 'elements' nie. Miskien moet dit duideliker gemaak word. Miskien duidelike afbakening of iets"* (participant 9).
[26] *"Ja, dit het sowat 4 ure se harde werk gekos"* (participant 14).
[27] *"Ek het gewerk in die tyd wat Mevrou vir ons die lab bespreek het. Ek het eintlik bedoel ek het teen my eie tempo gewerk. Ek het maar net aangehou totdat ek klaar was. Daar was niemand wat vir ons gesê het waar moet ons trek nie"* (participant 14).

> *I rushed through the last three answers. I didn't have more time. And I couldn't go back to some of which I was uncertain. It took me about four hours to go through everything*[28] (participant 9).

Although participant 9 did not regard this as dissatisfaction, it was considered too long for one session and, therefore, I interpreted it as inferred dissatisfaction. There was also some indication that the exercise at the end should be interactive, multiple-choice, instead of paper and pencil.

> *I would have liked it if there were multiple-choice questions in the exercise. Questions with more clues. Spelling should not have to be perfect*[29] (participant 9).

The responses to the questionnaire and the semi-structured interviews indicated to me that participants were dissatisfied with the following aspects of the tutorial (Addendum 2 and Addendum 4):

- its length;
- the time it takes to open from the Internet;
- limited navigational options; and
- lack of interactivity.

4.2.4 Conclusion

The conclusion derived at through analysing the data in support of answering research question 1 is summarised here:

- Despite participants' negative reactions about the time it took to open the tutorial from the Internet, they were highly motivated to work through the tutorial, implying their overall positive feelings about the tutorial. This was a clear indication of the participants' motivation and positive attitude towards the design tasks in the module. They thought that the tutorial was easy to use, which indicated their satisfaction with the programming of the tutorial.
- The semi-structured interviews confirmed what was found in the literature, i.e. despite negative responses to other aspects of the tutorial, participants considered the relevance of the tutorial as so important that they would revisit and reuse it for the rest of the module as well as for other modules in the programme (Clark, n.d.).
- From the participants' dissatisfaction with the above aspects of the tutorial I learned that,

[28] *"Ek het die laaste drie vrae afgerammel. Ek het nie meer tyd gehad nie. En ek kon nie teruggaan na party waarvan ek onseker was nie. Dit het my omtrent vier ure gevat om deur alles te kom."* (participant 9).
[29] *"Ek sou daarvan gehou het as daar meervoudige keuse vrae in die oefening was. Vrae met meer leidrade. Dit moet so wees dat spelling nie perfek hoef te wees nie"* (participant 9).

in order to maximise their satisfaction, and, therefore, their motivation to use the tutorial, some changes needed to be made. The tutorial should be shortened and presented in a different access format, and additional navigational options should be added. This would ensure that participants do not become discouraged because of their negative experiences and that they would not want to engage in the tutorial again. Kirkpatrick confirms the importance of eliminating negative reactions as far as possible, in order to prevent participants from not learning anything because of a negative reaction to the training (Kirkpatrick, 1994).

The second question, derived from the main research problem, will subsequently be discussed.

4.3 Research question 2: What are the implications of the participants' retention of knowledge towards possible improvement of the tutorial?

Sub-question 1: What knowledge was retained immediately after exposure to the tutorial?

Sub-question 2: What knowledge was retained after some time?

4.3.1 Data collection for research question 2

The data gathered for answering research question 2 are of a qualitative nature. Data informing me about the participants' immediate retention (sub-question 1) were derived from an exercise relating to visual analysis, consisting of fifteen questions answered on paper copy (Addendum 5). The written responses of the participants will be presented. Data are presented in the form of qualitative descriptions, explanations and interpretations, reflected against the recognised domain specific constructs and criteria (Addendum 6). For the purpose of this discussion, responses to three questions randomly chosen were analysed and interpreted (see figure 3.7 in chapter 3 for the analysing process regarding the immediate retention).

Data were gathered from a sequential test that required participants to visualise their understanding of some of the design principles and design elements. The responses, in the form of schematised drawings reflected participants' conceptual understanding of design principles, elements and techniques. These competencies were to be demonstrated after the completion of the tutorial. Participants' drawings and qualitative interpretations will be presented as part of this discussion.

4.3.2 Level 2: Learning

Kirkpatrick maintains that three learning objectives of training programmes should be strived for at the second level of evaluation:

> *Measuring learning therefore means determining one or more of the following: What knowledge was learned? What skills were developed or improved? What attitudes were changed?* (Kirkpatrick, 1994 p.42).

According to Kirkpatrick it is important to measure learning because no change in behaviour can be expected unless one or more of the above learning objectives have been accomplished by the participants: "Moreover, if we were to measure behaviour change (level 3) and not learning and if we found no change in behaviour, the likely conclusion is that no learning took place" (Kirkpatrick, 1994 p.42). From table 3.4 it can be seen that the three questions of the exercise discussed further on, established participant's immediate retention. It can also be seen that these three questions in the test measured participants' retention of specific design principles and elements after a period of time.

4.3.3 Discussion

The data presented now will support the argument that participants demonstrated immediate retention of the design principles; that they retained knowledge of design elements to a lesser degree; and showed very little evidence of understanding the use of techniques to realise design principles. I will draw on evidence from the exercise completed immediately after the intervention with the tutorial to support the discussion of research question 2.

4.3.3.1 Sub-question 1: What knowledge was retained immediately after exposure to the tutorial?

In this section, the three participants' responses to three questions in the visual analysis exercises completed directly after their first exposure to the tutorial will be presented. Evidence from the exercise supports the discussion. It will be argued that participants' retained knowledge about some design principles and design elements was average to fairly good, but that the retention of design techniques and the way in which techniques act as the manipulation of principles and elements to realise a particular visual effect, was poor (table 4.1).

In the responses to question 2, there was evidence of confusion between the two types of asymmetrical balance, indicating poor retention of the design principle balance explained in the tutorial:

*Symmetrical balance – shapes are repeated in the same positions on either side of a central vertical axis (*participant 9).

Participant 9's response indicated to me that this participant did not understand the design principle depicted in question 2, because the participant incorrectly identified/named it "symmetrical balance" instead of "asymmetrical balance". This demonstrates that the participant relied on her memory (incorrectly so) instead of on her conceptual understanding of how techniques are applied to create the principle "asymmetric balance" by referring to the specific elements used in this design.

There was also evidence that participants, although their retention of design principles was adequate, lacked understanding of how it was achieved and what underlying elements contribute to its structure:

- *Asymmetrical balance is achieved with dissimilar objects that have equal visual weight or eye attraction* (participant 14).
- *This design has asymmetrical balance, having dissimilar objects that have equal visual weight or equal eye attraction* (participant 21).

There was no indication that the above participants understood that techniques are applied to organise design elements on the format to realise a design principle, because the participants did not refer to any element specifically used in the illustration to substantiate their responses. In addition, these participants also used inappropriate terms for the design elements "shape" and "size", namely "objects".

The analysis of responses to question 9 of the exercise indicated that the participants demonstrated retention of some techniques applied, but did not retain knowledge and understanding of the design elements involved in a design, e.g.

- *The objects in the slide looks like they are moving and are repeated* (participant 9).
- *Figure repeated. Fuzzy outlines. Multiple images* (participant 14).
- *The figure has been repeated with a fuzzy outline of multiple images* (participant 21).

The participants were not required to identify the design principle realised in question 9. Their retention of the correct terminology pertaining to design elements was poor. They used terms like "objects" and "figures" instead of "shapes". Although they remembered some of the terms for the techniques used in the design, e.g. "repetition", they had not retained knowledge of terms such as "optical movement" in the tutorial, which they replaced by "look like they are moving". This indicated to me that participants retained understanding

of the concept as well as the effect of the appropriate technique used, although they did not necessarily remember the exact term used in the tutorial. There was also an indication that participants could identify some techniques by using the same terminology as in the tutorial, e.g. “repeated” “fuzzy” and “multiple”.

The third example, question 12, and the sample of responses to it is discussed below. The image in question 12 appeared elsewhere in the tutorial, in slide 22, as illustration of scale and proportion and was, therefore, a familiar image to the participants.

Good retention of design principles, but not of the design elements, was evident from the responses below:

- *Small human figure against the huge sunflower shows how relative the concept of size is. The light areas represent smoothness and dark represents roughness* (participant 9).
- *Unrealistic proportions of the small human figure against the huge flower size. It creates surface quality* (participant 14).

The responses of participants 9 and 14 indicated to me that there was little understanding of the visual effect that technique has on the design elements. Neither of the participants quoted above recognised the type of texture applied here, i.e. tactile texture, and failed to recognise the interrelationship between proportion, technique and texture.

However, signs of good retention of design elements could be seen in the response of participant 9:

> *Texture: it looks as if you can actually touch it. The little man that is small emphasises the sizes and proportions of objects compared to each other* (participant 9).

Partial retention of design elements was evident in the response above. Participant 21 described tactile texture without using the correct terminology. This meant that the participant understood the concept. It was also a demonstration of her understanding of the function of scale in the design.

An analysis of all the responses of participants 9, 14 and 21, and how it related to their conceptual understanding of all the constructs involved in the exercise, are summarised and rated in table 4.7. The rating used was:

- 0 - 2 = poor (no understanding of any of the concepts required);

- 3 = fair (could identify some of the concepts (principles and elements) correctly, but without reference to detail of technique used;
- 4 – 5 = good (clear understanding of most concepts and reference to detail specifics of the designs).

Table 4.1 indicates that participants 9 and 14 had poor to average retention of design principles and design elements, and poor understanding of the interrelationship between principle, elements and techniques to create a particular visual effect, whereas participant 21 demonstrated good retention of design principles, fair to good retention of design elements and good understanding of how techniques are used to create visual effect.

Table 4.1 Summary of participants' conceptual understanding of all the constructs in the exercise

Design principles	**Participant 9**	**Participant 14**	**Participant 21**
Unity	Poor	Fair	Good
Balance	None	Poor	Good
Illusion of motion	Poor	Fair	Good
Proportion	Good	None	Poor
Design elements			
Shape	Good	None	Good
Line	Fair	Good	Fair
Texture	Fair	None	None
Colour/tonal value	Not clear	None	Good
Rhythm	None	Fair	Fair
Techniques			
Contrast	None	None	Good
Repetition	Good	None	Good

Participants' responses to the exercise indicated to me that their immediate retention of the three main constructs, design principles, elements and techniques varied:

- principles – fairly good on average;
- elements – fairly poor on average; and
- techniques – very poor on average.

I learned from this that they could identify most design principles fairly well; they could not distinguish between design principles and design elements well and in most cases design elements were known fairly poorly. Their knowledge and understanding of the concept "design techniques" (explaining "how") was very poor at this stage of the module. I learned from this that they did not yet understand that the techniques were used to manipulate spatial arrangements (Tversky, 1999):

- repetition;
- addition;

- omission;
- distortion;
- enlargement; and
- diminution.

Subsequently sub-question 2 will be addressed.

4.3.3.2 Sub-question 2: What knowledge was retained after a period of time?

On the second level of learning, according to the augmented framework of Kirkpatrick's (1994) evaluation model, participants' demonstrated capability in the context of the module under discussion. For this purpose I examined the responses to a sequential test two weeks after the first exposure to the tutorial, testing two design skills:

- visual analysis identifying, explaining and describing constructs; and
- free-hand drawings schematising constructs.

The test consisted of a criterion-based section consisting of two sections pertaining to this study. The first was a section of three questions testing participants' development in visual analysis. The second section consisted of four questions requiring participants to draw their understanding of design constructs. The discussion that follows will take place in this order.

Visual analysis

The questions in the test under discussion were completely open-ended and non-directed. Students were given three images of designs that they had to analyse and discuss without directing them in any way towards specific constructs in operation. This presented difficulty in the research as there were numerous possible combinations and relationships (Tversky, 1999) that could not be foreseen. The coding system in table 3.15 in chapter 3 was, therefore, closely followed to validate the interpretation of responses. The trends emerging from analysing the responses to the visual analysis questions in the test will now be discussed.

At the time of the test, varying degrees of ability to distinguish between the constructs, design principles and elements were evident. Confusion between design principles and elements were apparent in students identifying symmetric balance as a design element instead of a design principle in question 5.2:

> *The design element used for this is symmetric balance because the shape of the wine glass on both sides of the vertical line is the same…*[30] (participant 9).

When asked to identify the design principles and explain which design elements were used to realise the principles, the majority were able to identify the design elements, e.g.

> *The design principles are balance and unity. The design elements used to achieve this are repetition, a focal point, continuation, transparency and colour…*[31] (participant 9).

However, while they were mostly able to identify many of the design elements in question 5.3, some could identify only the design principle rhythm in this question correctly, not being able to identify unity and balance:

> *The elements used to achieve this design was colour, the colour had to blend in with the design. There is shape because the designer made use of a lot of line. Its appearance looks as if it has a rather rough texture. It definitely has rhythm because your eye moves across it in a rhythmic way*[32] (participant 14).

Understanding the design principle of balance remained a problem to some participants. Some still did not know the difference between symmetrical and asymmetrical balance. The response below indicates that participant 21 only considered one object in the design, and did not consider the variety of elements making up the whole design and contributing to the creation of balance (participant 21 only considered the wine glass and not the rest of the objects/elements in its vicinity):

> *Symmetrical balance has been achieved by the wine glass placed in the centre of the design (*participant 21).

If the participant had considered all the elements at play in the design, the participant might have identified the type of balance correctly as asymmetrical. However, the response quoted above indicates that understanding of how the balance was created in the design was still poor and evident in the incorrect explanations. These were due to failure in considering that

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[30] *Die ontwerpelemente gebruik hiervoor is simetriese balans omdat die vorm van die wynglas aan albei kante van die vertikale lyn dieselfde is ..."* (participant 9).

[31] *Die ontwerpbeginsels is balans en eenheid. Die ontwerpelemente wat gebruik is om dit te verkry is repetisie, 'n fokuspunt, kontinuasie, transpiransie en ook kleur* (participant 9).

[32] *Die elemente wat gebruik is om die ontwerp te bereik was kleur, die kleur moes inskakel by the ontwerp. Daar is vorm in die ontwerp omdat die ontwerper van baie lyn gebruik gemaak het. Sy voorkoms lyk asof dit nogal 'n growwe tekstuur het. Hy het definitief ritme omdat jou oog oor hom beweeg op 'n ritmiese manier* (participant 14).

there were many dissimilar objects created by a variety of elements and techniques in the two sides of the axis of the design in question 5.2, and not only one:

> *Visual balance is achieved by the dark coloured strip in comparison with the busy focal point in the top half of the picture; therefore, colour is an important role…*[33] (participant 9).

Although participants' responses to the three questions under discussion still contained elements of vagueness and uncertainty, it seemed as though increased awareness of detail was evident in the specificity of the descriptions and explanations of the designs. Prevailing uncertainty could be seen in the following responses:

- *The transparency causes the focal point and thus gives visual balance, the repetition of the photographs in the blocks creates unity, the colour of the blocks where some are light and others dark, creates unity and the repetition of the photographs give unity*[34] (participant 9's response to question 5.1).
- *They made use of size and shape that are balanced against one another, which forms a unity. The design has volume and there is also an element of colour as well as rhythm. The element of motion also comes in here because the grapes form a repetitive pattern*[35] (participant 14's response to question 5.2).
- *The tee pot has rhythm as a result of the play with colours and the pattern that guides your eyes. The design has volume because it is 3-dimensional*[36] (participant 14).

Participant 9's statement that "transparency causes the focal point and thus gives visual balance" indicates that the participant does not understand

- that "focal point" and "balance" are both design principles; and
- that one principle can not "cause" another, but are being created in the way elements are used.

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[33] *Visuele balans word verkry deur die donkerkleurige strook in vergelyking met die besige fokuspunt in die boonste helfte van die prent, dus is die kleur 'n belangrike rol* (participant 9).

[34] *Die transpirasie veroorsaak die fokuspunt en gee dus visuele balans, die repetisie van die fotos in die blokkies skep eenheid, die kleur van die blokkies waar party lig en ander donker is skep eenheid en die fotos wat herhaal word gee eenheid* (participant 9)

[35] *Hulle het gebruik gemaak van grootte en vorm wat teenoor mekaar gebalanseer word wat 'n eenheid vorm. Die ontwerp het volume en daar is ook 'n element van kleur asook ritme. Die element van beweging kom ook hier voor omdat die druiwe 'n repiterende patroon vorm* (participant 14).

[36] *Die tee pot het ritme a.g.v. die speling met kleure en patroon wat jou oë lei. Die ontwerp het volume omdat hy 3 dimensioneel is.* (participant 14).

The vagueness in participant 9's referencing and lack of specifics can also be seen in the above response to question 5.1. There is no indication of what it is in the design that the participant considered as the "focal point" or in which elements (e.g. shapes, sizes, tonal value) the "balance" was seen.

Participant 14's response to question 5.2 was equally vague. The statement "They made use of size and shape that are balanced against one another, which forms a unity" was non-specific. There was no explanation of how size and shape were used or how balance was created. The participant also made the conceptual mistake to ascribe the creation of one design principle, "unity", by another principle, "balance".

A lack of reference to detail was evident in participant 21's response. There was neither an explanation of how there was "played with colours and pattern" nor any explanation of what was meant by "volume" and how it relates to 3-D. This was also evident in participant 14's response to question 5.3.

From the above responses it was evident that some participants did not grasp the intricate interplay between design principles, design elements and techniques on a format. However, some participants' responses indicated an emerging increase in sensitivity for detail. This could be seen in their use of appropriate terminology; detailed references to specific elements and techniques in the design and insightful explanations of how techniques were used in establishing design principles. An example of such increase in sensitivity for detail is evident in participant 21's response to question 5.1:

> *Unity has been achieved in their design - this has been achieved by the repetition of the square shape in which the images are set. It has also been created by the continuation of the line behind the images. An illusion of space has been created by the transparentness of the images. Balance has been achieved through the equal scale of each square and the fact that the squares are proportionate to one another. Rhythm has been created through the regular repetition of the squares* (participant 21).

In addition, clear reference in explanations to specifics seen in the designs supported the emerging indication of clarity of understanding. Explicit explanation in responses to question 5.2 and 5.3 verbalised that the design principle "unity" is caused by the similarity of the shapes in proximity to each other:

- *In this design the wine glass shape reflects the shape of the woman's neck and this creates unity, because the two are a similar shape and are placed close to one another* (participant 21, question 5.2).
- *…and then unity is achieved through the shapes because all the shapes are then put together in one focal point* (participant 21, question 5.2).
- *The shape of the handle is also similar to the shape of the spout and this creates unity* (participant 21, question 5.3).

Participants 9 also demonstrated increasing sensitivity for detail in the description of the design in question 5.2 relating to texture namely how texture can be created:

> *… there is also texture in the round grapes and transparency of the woman's face that is abstract*[37] (participant 9).

One response to question 5.3, however, indicated emerging understanding of the techniques used to realise balance by referring to elements moving in different directions in space:

> *Balance in this design has been achieved by the spout going out in one direction and a part of the handle going out in another* (participant 21).

Similarly some sensitivity to the visual effect of technique and design elements on the viewer was increasing:

> *An illusion of space has been created by the transparency of the bowl. These shapes guide the viewer's eye from the heading to the bowl of the wine glass (woman's head) (*participant 21, question 5.2).

Participants' responses to the visual analysis questions in the test indicated the following pertaining their retention of knowledge after a period of time:

- they could not differentiate well between design principles and elements;
- they could identify most design elements;
- the design principle "balance" was not understood yet;
- there was an emerging increase in sensitivity to detail;
- some understanding of the purposeful use of techniques to create specific principles was emerging; and
- they could transfer some knowledge from 2-D designs to 3-D objects.

[37] *… daar is ook tekstuur in die ronde druiwe en transpiransie van die vrou se gesig wat abstrak is* (participant 9).

Drawings

Drawings use a small number of segments or elements in varying combinations to produce a potentially infinite set of different drawings. Studying the segments of sketches give insight into what conceptual modules are operative and how they are schematised (Tversky, 1999, p.6). In this study, I analysed the following constructs as segments of participants' drawings:

- design elements;
- design principles;
- techniques; and
- ways of arrangement on the format;

in order to establish

- how much knowledge they retained;
- what their conceptual understanding of the constructs were; and
- the skills and intent evident towards realising a particular design principle.

In this section it will be argued that:

- Participants, who reproduced the examples in the tutorial accurately, did not necessarily have better conceptual understanding of the constructs tested.
- Schemas not resembling the examples in the tutorial closely, but realised the design principle in question by using other design elements, techniques and arrangements on the format, demonstrated intent as well as conceptual understanding.

Schemas of participants' understanding of how to visualise the design principles "unity, asymmetrical balance" and "visual texture" will be presented and analysed.

Discussion

In the same test as discussed in the previous section (4.3.4.2, Visual analysis) a second section consisting of three questions, required participants to demonstrate knowledge, understanding and visualising skills of specific design principles, elements and techniques through visualisation or drawing schemas. I designed directed drawing tasks towards specific design principles and design elements and techniques in order to gather information about the segments (Tversky, 1999) of the constructs in their schemas (drawings). I wanted to know:

- What participants learned about the design principle "unity"?
- What participants learned about the design elements "shape, size, pattern, tonal value, line" and "texture"?
- What techniques could they implement to manipulate the elements and arrange them in such a way that the design principle required is realised?

Information about the above questions would help me to establish (1) what the participants knew and understood about the underlying conceptual structure of the domain of aesthetics in product design (Tversky, 1999), and (2) how the tutorial contributed to their knowledge and understanding.

The drawing tasks in the test were:

- Question 1: Illustrate the design principle "unity" achieved through "shape" and "pattern".
- Question 2: Illustrate the design principle "asymmetrical balance" achieved through "size" and "tonal value".
- Question 3: Illustrate the design principle "visual texture" achieved through "line, tonal value" and "shape".

In order to ensure validity and reliability, I created a coding system that I used for evaluating the drawings in the test (table 3.14 in chapter 3).

Participants' responses to question 1 indicated that they were able to create the principle of "unity" fairly well. Analysing their schemas and comparing them to slides in the tutorial (Addendum 14) indicated that they had good retention of the constructs used in the tutorial illustrating the design principle "unity".

Participant 9 was successful in purposeful application of the technique "repetition", by repeating the design elements "shape, line" and "tonal value" (figure 4.1). The participant arranged it in such a way on the format that the pattern of open and filled rectangular shapes that were created closely resembled the design of the woven wire construction in slide 9 in the tutorial illustrating the principle "unity without variety" (figure 4.2).

On the other hand, it seemed as if participant 14 recalled the design on slide 14 of the tutorial (figure 4.4) and schematised her recall as illustrated in figure 4.3. It is evident that the participant imitated the general shape of the basket in figure 4.4 and used the same spherical shape, on which she arranged rectangular shapes in patterns forming rows, very similar to the design in figure 4.4. It is apparent that participant 14 understood the design principle of unity by adding her own elements, namely the circular shapes as a handle for the lid of the basket, which is similar in size and shape to the circular shapes on the horizontal lines running in between rectangular shapes on the basket itself.

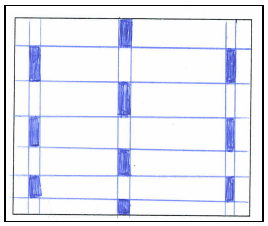


Figure 4.1 Participant 9's schema the design principle "unity"

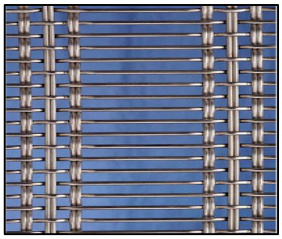


Figure 4.2 Image in tutorial illustrating the design principle "unity without variation" (slide 9)

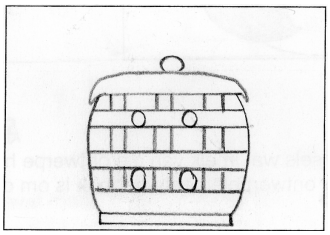


Figure 4.3 Participant 14's schema of the design principle "unity"

Figure 4.4 Image in the tutorial depicting the design principle "unity" (with emphasis on unity) (slide 14)

In contrast to the examples of unity without variation in the tutorial recalled by participants 9 and 14, participant 21 seemed to have recalled an example illustrating the principle "unity with variety" (figure 4.6).

From this response it was evident that the participant not only recalled the image in the tutorial well, but that the participant also understood how purposeful arrangement of the design elements could contribute to realising the principle "unity with variety", preventing the viewer from getting visually uninterested (Addendum 14, slide 13). Participant 21 used the technique of repetition to create patters of line and shape, and added variation to the unity by placing a dark rectangular shape as a "surprise" element (variety) on the format.

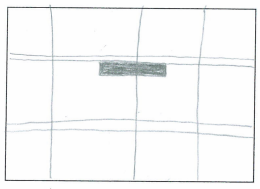


Figure 4.5 Participant 21's schema of the design principle "unity with variation"

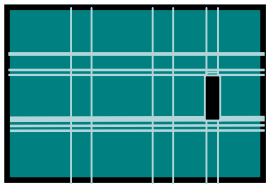


Figure 4.6 Image in tutorial illustrating the design principle "unity without variation" (slide 13)

The second question in the test on drawing directed participants to visualise the design principle of "asymmetrical balance" through the use of the elements "size" and "tonal value". Although there was four designs in the tutorial illustrating the principle "asymmetrical balance", it seemed that there was one image recalled by more participants than any other design, namely the one in figure 4.8.

Participants 9 (figure 4.7) and 14 (figure 4.9) seemed to have had good recall of the techniques implemented as well as the way in which elements were arranged around the horizontal axis to achieve asymmetrical balance. However, both participants used fewer elements than used in slide 21 (addendum 14). The techniques recalled were that of repetition and of reversal. The design elements used were shape, line and tonal value. Both participants managed to arrange the elements in such a way on the format that asymmetrical balance was successfully realised.

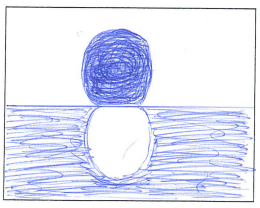


Figure 4.7 Participant 9's schema of the design principle "asymmetrical balance"

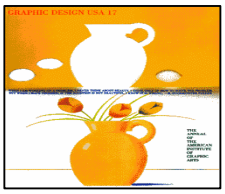


Figure 4.8 Image on the tutorial of the tutorial illustrating asymmetrical balance (slide 21)

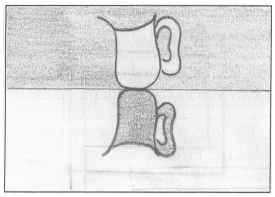


Figure 4.9 Participant 14's schema of the design principle "asymmetrical balance"

The schema in figure 4.9 indicated participant 14's good recall of the example in the tutorial (figure 4.8) and how asymmetrical balance was achieved by using the elements "tonal value" and "shape". The resemblances can be seen in the way these elements were arranged around the horizontal axis of the format. In both images a medium tonal value in the

background of the top half of the format is balanced with a white background with medium-dark shape at the bottom. Neither of the participants' schema attempted to add new or different elements or arrangements than those in figure 4.8.

Contrary to this, participant 21 demonstrated her understanding of asymmetrical balance by implementing other techniques and arrangements of the same elements as the schemas in the tutorial. Figure 4.10 illustrates how participant 21 visualised the principle.

In the schema in figure 4.10, the shapes are placed at a diagonal angle from one another around the invisible horizontal axis, and not in a straight angle as in slide 21 (figure 4.8). Participant 21 also manipulated the sizes of the shapes to be completely different from one another, unlike the exact same sizes used for the dominating shapes in figure 4.8. This participant used tonal value to contribute to the visual balance by placing the small dark shape in the top right half of the format, balancing it with the larger white shape in the left bottom corner of the format.

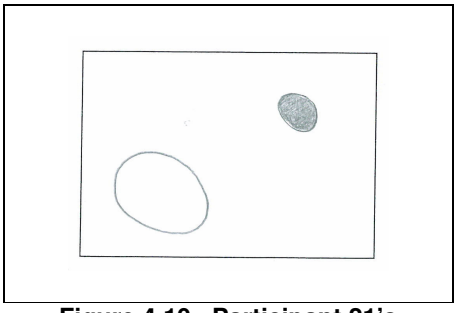


Figure 4.10 Participant 21's schema of the design principle "asymmetrical balance"

In question 3 of the test students were required to illustrate the design principle of visual texture achieved through line, tonal value and shape. The many different ways in which it is possible to combine and arrange the small number of design elements on the format in order to realise the same design principle, was evident in the different responses examined.

I found it more difficult to establish which of the designs in the tutorial illustrating visual texture, seemed to have been recalled. However, from close analysis of each schema in the responses, some resemblances emerged. It seemed as though participant 9's schema (figure 4.11) resembled some aspects of the image in figure 4.12 (Addendum 14, slide 33), illustrating the principle "visual texture" closest.

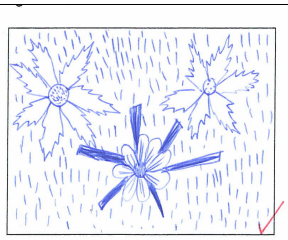


Figure 4.11 Participant 9's schema of the design element "visual texture"

Figure 4.12 Image on the tutorial depicting the design element "visual texture" (slide 33)

Recall of slide 33 (figure 4.12) was evident in the similarities between the schema of the student and that in the tutorial. Similarities are, e.g. the use of the elements "line" and "tonal value". Small, short dark lines in the background with lighter tones in between, creating visual texture, i.e. texture that can be seen, but not felt (Addendum 14, slide 32). In addition, both schemas used a shape resembling a flower on top of the texturised background; in the case of the image in the tutorial, the shape of a disa flower emerges from the white square shape, while participant 9 arranged three different flower-shapes randomly on top of the textured background, indicating a good understanding of how to visualise the design principle "visual texture" by using the elements "line, tonal value" and "shape". This participant successfully realised the principle "visual texture".

Some participants managed to visualise their understanding of the element of visual texture in a complete abstract way, not resembling any particular image in the tutorial, and yet creating a schema appropriately by using the required elements in completely new and abstract arrangements. Figure 4.13 illustrates the successful abstraction of the concept "visual texture" by participant 21.

The participant manages to draw three different schemas on the same format, using the element "line" to create shape and tonal value through density of her marks. Each schema differs in shape and organisation as well as the way lines run in different directions and spaced in a variety of ways, thus contributing to the illusion of visual texture. The participant uses shape in an abstract way, not resembling an object as seen in participant 9's schema (figure 4.13).

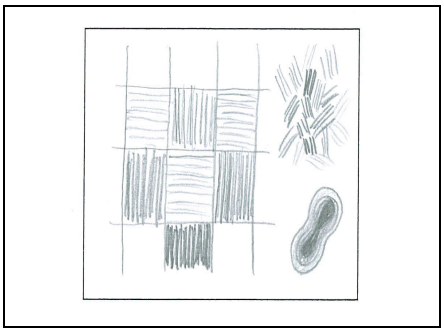


Figure 4.13 Participant 21's schema of the design element "visual texture"

In contrast to this, some participants did not seem to know the difference between the principle "visual texture" and "tactile texture". This is evident in the schema of participant 14, illustrated in figure 4.14. Close analysis of the schema indicated greater similarities to the image in figure 4.15, which illustrates the element of tactile texture.

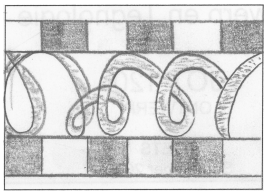


Figure 4.14 Participant 14's schema of the design element "visual texture"

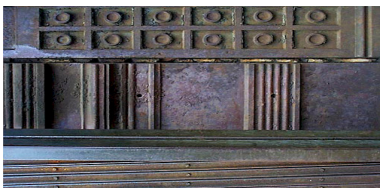


Figure 4.15 Image on the tutorial illustrating the design element "tactile texture" (slide 34)

The similarities between the two schemas were imbedded in the way in which participant 14 used the elements "line, shape" and "tonal value" to resemble her understanding of raised areas and sunken areas on a tactile surface. The participant seemed to have enlarged certain elements, namely the white and medium-dark toned rectangular shapes in border-like patterns on both sides of curling medium-light toned lines creating a distinct feeling of a surface texture that can be felt when touched. It was the illusion of large flat raised areas on the format resembling the large flat raised areas in the image in the tutorial that indicated her recall of figure 4.12, illustrating tactile texture instead of visual texture (figure 4.15).

In summary it could be said that the drawings indicated that all the participants knew the design principles. However, not everyone recalled the design element "visual texture". It

was further evident that participants in most cases recalled a specific design in the tutorial illustrating the particular design principle/element in question.

4.3.4 Conclusion

The conclusion derived at answering research question 2 was supported by analysing the data on immediate retention and learning after a period of time, is presented here. The findings indicate significant correlations between learning on the immediate retention level and that of learning after a period of time pertaining to their understanding of the constructs of the domain under discussion:

- participants knew the design principles fairly well, except for the concept "balance", which seemed to be problematic for some in both stages;
- participants knew most of the design elements fairly well, except for "texture" which seemed to be problematic for some on the level of learning after a period of time;
- knowledge of how design techniques are implemented to manipulate elements and arrangements on the format started to emerge in the visual analysis as well as in the drawings at the level of learning after a period of time, which demonstrated an improvement from the level of immediate retention when knowledge seemed to be very poor; and
- there seemed visible evidence of the contribution that the tutorial made on the immediate retention of knowledge as well as in learning after a period of time.

4.4 Research Question 3: What are the implications of participants' behaviour/transfer for possible improvement of the tutorial?

Sub-question 1: How was knowledge transferred to participants' designs for their projects?

Sub-question 2: What was the sustained change in behaviour in the end-of-year examination?

4.4.1 Data collection for research question 3

The different activities in the module under discussion, which were focused on demonstrating the transfer of knowledge and sustained change in behaviour, will now be discussed. Data for establishing the transfer that had taken place were drawn from representational drawings[38] of designs for a project. Data for establishing whether the participants' ability to transfer knowledge demonstrated in the project could be sustained in a new situation were

[38] Representational drawings "show your intentions..." (Caborn *et al.*, 1989 p.32).

drawn from preliminary drawings[39] in the end-of-year examination. For analysing and interpreting the data for research question 3, I used the same procedure and system as were used to analyse the drawings discussed in section 4.3.2. (See table 3.14 in chapter 3 for the coding system used.)

4.4.2 Level 3: Behaviour/transfer

Participants' capabilities to apply the design principles and design elements in their own designs in their projects and in a sequential examination were designed in order to establish the extent to which participants' design skills had improved during the course of the module, as a result of the intervention with the tutorial.

Kirkpatrick names the third level in learning "behaviour". He describes behaviour evaluation as the extent to which trainees applied the learning and changed their behaviour immediately after and several months after the training, depending on the situation (Kirkpatrick, 1994).

4.4.3 Discussion

In the discussion that follows, I will analyse and discuss the representational drawings of the three participants under discussion. I will analyse and discuss what transfer of knowledge had taken place in their 3-D designs of different lamps. From the data presented, research question 3: "What are the implications of participants' behaviour/transfer for possible improvement of the tutorial?", will be answered.

4.4.3.1 Sub-question 1: How was knowledge transferred to participants' projects?

In the discussion that follows, it will be argued that participants retained their knowledge and were able to differentiate between the various design elements and could draw from their previous experience in order to develop better conceptual understanding of the constructs specific to the domain of aesthetics in design environments.

The representational drawings in the project indicated that although participants retained knowledge of the design principles and design elements fairly well, they failed to add much visual interest to their designs because of a lack of contrast and anomaly that usually prevent visual boredom on the side of the viewer (Wong, 1993).

Participant 9's portrayal of her lamp design reveals the design principles and design elements clearly. This participant's representational drawing (figure 4.16) depicts a

[39] Preliminary drawings "includes a simple investigation of the problem ..." and "are used to convey information related to shape, form and overall appearance" (Caborn *et al*., 1989 p.32).

magenta-coloured square box-shaped lamp. The participant manages to create unity by using the same transparent tissue paper on all sides, contrasting its thin visual weight and colour with the heavy visual weight of the brown bamboo frame. The lines of the bamboo frame form a decorative border. The repetitive use of the black coloured rope and the way in which it is tied around the connecting bamboo sticks, creates a pattern and adds visual interest to the design. Symmetrical balance is achieved by the equally visual weight around the vertical and horizontal axis.

The participant represented the idea clearly and with sufficiently clarity. It is evident that participant 9's intention was to design a transparent magenta box-like lamp with a bamboo frame tied with string and standing directly on the surface. However, in spite of her clarity and successful realisation of some design principles, this design lacks visual interest due to its emphasis on unity without variety through contrast or anomaly (Wong, 1993).

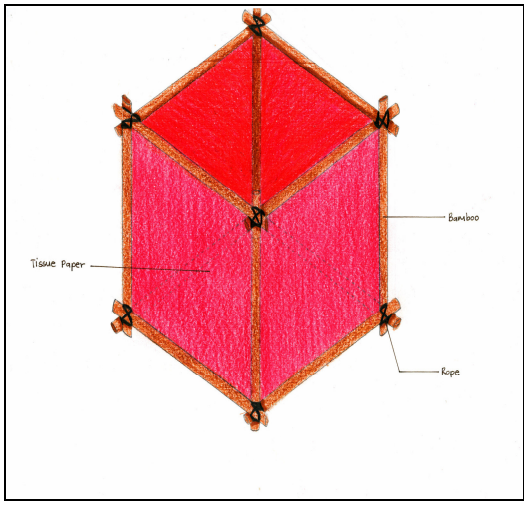


Figure 4.16 Participant 9's representational drawing in the design phase of the project

An analysis of participant 14's design in figure 4.17 demonstrates that the participant successfully revealed the design elements and its appropriate arrangement in order to realise particular design principles. This participant achieved unity by using the curved line at the bottom, repeated in the curvature of the sides of the lamp, as well as in the decoration at the top. Participant 14 created unity with variety by including straight lines in the "windows" or holes where the light would shine through. Symmetrical balance was created by the way in which participant 14 arranged the negative spaces around the vertical axis of each segment of the lamp. Horizontal asymmetry was achieved by her use of tonal value, placing the darker (and heavier) black at the bottom and gradually introducing lighter red and

yellow. This participant's use of shape and size also contributes to asymmetrical balance. In addition, the way in which the participant places the wider half-circular shaped negative spaces at the bottom of the lamp also supports the concept of visual balance asking for heavier shapes to be at the bottom of a format rather than at the top. This creation of scale through the negative and positive spaces in relation to each other indicates participant 14's sense of proportion. There was an equal distribution of visual weight around the vertical axis at any of the six sides of the lamp. Horizontally the yellow light shining through the "windows" asymmetrically balanced the black at the bottom.

Participant 14 represented the idea clearly and with sufficient clarity. It is evident that this participant intended to design a lamp that resembled a building/tower standing directly on the surface. However, the design also lacks visual interest due to limited variation of technique and lack of contrasting elements (Wong, 1993).

In contrast to the two previously discussed designs, the drawing by participant 21 represented more visual interest, while at the same time revealing the design elements and principles clearly (Tversky, 1999). This participant also successfully revealed the idea with clarity.

Participant 21 created various design principles, namely unity, balance, illusion of movement, rhythm, scale and proportion. The participant arranged numerous design elements by applying techniques creatively; namely repetition, change of direction, contrasting scale by repeating the design elements of colour and shape in order to create unifying patterns. The participant repeated the decorative wavy pattern resembling waves, suggesting movement (in correspondence with her marine theme) at the top and the bottom of the shade.

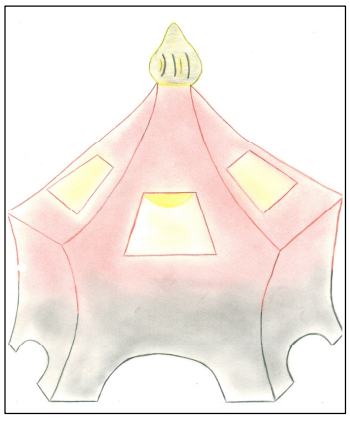


Figure 4.17 Participant 14's representational drawing in the design phase of the project

Participant 21 also repeated the cut-out shapes of the stylised fish. All the shapes used in this design were geometrical and stylised, contributing to the unity in the design. The background colour of the shade was ultramarine, supporting the marine theme. The round shape of the lampshade also suggested movement. This participant achieved asymmetrical balance around the horizontal axis by using different shapes and sizes of the cut-outs bearing equal visual weight, on the unifying background colour and patterned border. This subtle asymmetry contributed to the visual interest of the design. Visual interest was further created by the contrast in scale. The big, solid shapes of the top and bottom of the shade, contrasted with the small scale of the cut-outs. There was no single focal point in the design. The design rather kept the viewer's eye moving around the whole format, interest being maintained by the subtle variation in direction of the wavy pattern bordering the top and bottom of the lamp as well as of the negative space of the fish.

The representational drawings of the project indicated to me that transfer of knowledge had taken place. Participants were able to transfer their knowledge of design principles, design elements and design techniques they have learned through 2-D designs in the tutorial to 3-D designs as visualised in real 3-D space. They managed to demonstrate this transfer of knowledge because their drawings:

- revealed the design elements and techniques clearly;
- represented the ideas well; and
- were sufficiently clear.

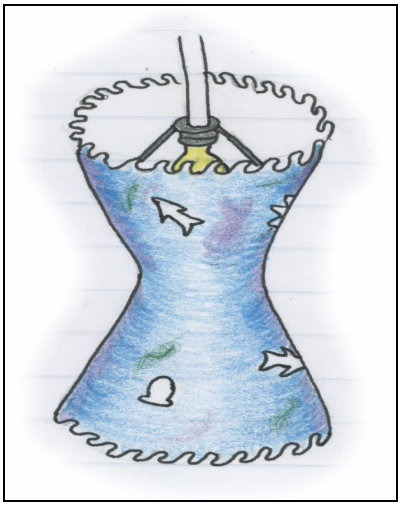


Figure 4.18 Participant 21's representational drawing in the design phase of the project

However, except in the case of one participant, there was a general lack of visual interest in participants' designs. They were uninteresting and visually boring due to a lack of variety of techniques and contrasting elements.

4.4.3.2 Sub-question 2: Was the changed behaviour sustained?

In the discussion that follows, I will analyse and discuss preliminary free-hand pencil drawings of a lamp designed for a different purpose than those designed in the participants' projects. From the data presented, research question 3 will now be answered.

It will be argued that participants sustained transfer of knowledge by revealing design principles, design elements and techniques with clarity. It will also be argued that:

- creating balance in 3-D objects is problematic;
- some improvement in the visual interest in their designs was evident;
- although not everybody could represent their ideas clearly enough, there was enough evidence of other improvement in order to infer that there was a change in participants' behaviour.

The exploratory drawing by participant 14 (figure 4.19) is an example of poor behavioural change. Although the participant managed to reveal the minimum design principles, elements and techniques required by the problem statement, this participant could represent the idea with limited success. In addition the participant lacked the technical skill to convey 3-D shapes convincingly. Visual interest was also evident in a limited way.

Participant 14 managed to reveal the design elements and techniques used to realise some design principles. The participant realised the principle "unity" by repeating the idea of nature through the organic shape of the connecting piece running from the electric fitting to the lampshade and the texturised geometric leaves on the edge of the shade. Emphasising the leaves created a focal point. This was achieved by guiding the viewer's eye (through the illusion of movement in the organic shape of the connecting piece) to the front of the design and the edge of the shade. There is no symmetry in the design indicating that the participant knew the difference between symmetry and asymmetry. Her design, although demonstrating an attempt at realising asymmetrical balance, is not well balanced due to the fact that too much visual weight is put on the front edge of the lampshade. The wide side of the triangular shape at the front, together with the heavy shapes of the leaves, is not sufficiently balanced by the shapes and their sizes to the back of the shade and connecting piece. The shape of the shade together with the placement of the connecting piece defies her attempt at realising asymmetrical balance.

Participant 9's design was not represented with sufficient clarity. It was not clear where the light would be shining through. The participant also failed to convince the viewer of the 3-D shape of the shade due to her inability to apply the elements "line" and "tonal value" to support the round shape of the triangular shade. In spite of this lack of technical drawing skills, the participant represents the idea clearly enough to let the viewer understand how the connecting piece should fit into the shade and into the electrical fitting. Participant 9 brought limited visual interest into the design through the geometric shape of the shade contrasted by the organic shape of the connecting piece. There was limited use of texture, line and movement, categorising this as a weak design with very little visual interest and little improvement from the design in the project discussed previously. The participant also failed to indicate how the electrical parts inside the lamp were envisaged. It was not clear where and how the electrical fitting in the shade would function.

In contrast to the weak design by participant 14, significant improvement was evident in the exploratory drawing by participant 9 (figure 4.20). Although the participant's one-point perspective drawing seemed to distort the design somewhat, there was sufficient evidence of skill and knowledge to convince the viewer of the intent. Participant 9 revealed the design elements and techniques used to realise particular design principles with conviction. Unity was achieved through the repetition of the rectangular shapes in the stand; line was created by the clear edges of the shapes, rhythm through the pattern of solids and open textured areas in the shade and the stand and through contrasting tonal values in both the stand and the shade.

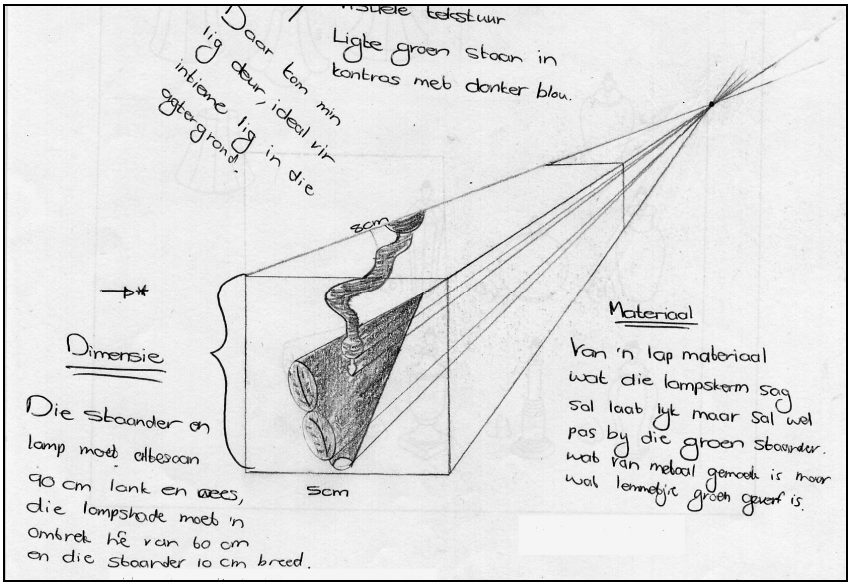


Figure 4.19 **Participant 14's exploratory drawing in the end-of-year examination**

Asymmetric balance was achieved successfully through the equal spread of visual weight around the horizontal axis of the design. The long, narrow shape of the stand balances the large, wide oval shape of the shade. Emphasis on the shade was created by the sudden contrast between rectangular shapes in the stand and the oval shape of the shade. Attention was further drawn to the shade by direction of the textured pattern running horizontally around the shade.

The participant represented the idea well. The 3-D shape was convincingly conveyed through her skilled use of line and tonal value. The shade's oval shape was created convincingly by modelling the shape with line. Visual depth was created by darker areas where light failed to reach and light areas where light is reflected most, supporting the definition of shape and size. Visual interest was created by the big variety of contrasting elements and techniques in the design. The participant contrasted solid areas with open, textured areas; direction of pattern is changed in the stand and the shade; eye movement ensured by the textured pattern in the shade running around the shade and guiding the viewer's eye around the whole design. In addition to this, it is clear to the viewer how the participant envisaged the electrical fitting in the shade. Participant 9 demonstrated significant improvement in realising visual interest by combining design elements and techniques in a creative and novel way.

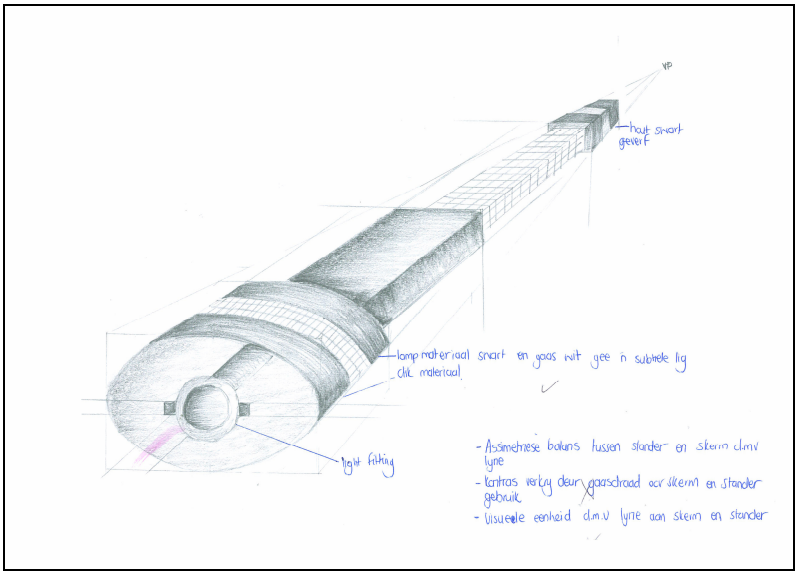


Figure 4.20 **Participant 9's exploratory drawing in the end-of-year examination**

On the other hand, participant 21's exploratory drawing in the end-of-year-exam (figure 4.21) exemplifies sustained transfer of knowledge, without significant improvement since the evaluation in the project, discussed previously, although it was already fairly good, as indicated in the earlier discussion.

This participant created unity by repetitively use of the same organic quality in the design evident in the shape, pattern and texture of the shade and the stand. Emphasis was put on the shade by the wavy pattern guiding the viewer's eye around the whole shade. By balancing the short, wide shape of the shade with the longer and thinner stand, the participant created asymmetrical balance around the horizontal axis. However, the long flat part of the shade resting on the surface was disturbing and its excessive length somewhat defied the balance created. Rhythm was successfully created by the repetitive curve in the shape of the linear pattern on the shade as well as by the round shape in the organic pattern in the stand.

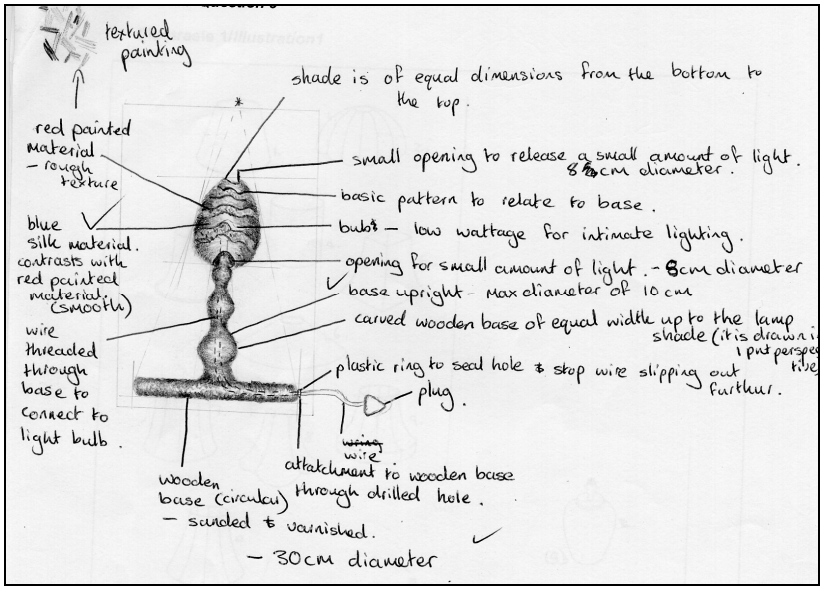


Figure 4.21 **Participant 21's exploratory drawing in the end-of-year examination**

Participant 21's idea was presented clearly in her drawing. She created shape successfully through line and tonal value. With a variety of marks she managed to define the 3-D shape as well as the texture of the shade and the stand. Using darker tones for areas where light is not reflected and lighter tones where light is reflected created depth.

The participant used the technique of contrast and variety in texture to create visual interest in her design. However, it seemed that contrast is not big enough to make it as visually exciting as in the design by participant 9 discussed previously. This is due to the fact that

there is an over-emphasis on repeating similarities and unity without any elements of surprise.

4.4.4 Conclusion

The conclusion derived at answering research question 3 was supported by analysing the data of representational drawings in projects and exploratory drawings of lamp designs in the end-of-year examination. The findings indicated that transfer of knowledge had taken place in the projects. Participants were able to transfer their knowledge by revealing the design principles, design elements and some of the techniques clearly. They represented their ideas fairly well with sufficient clarity. However, except in the case of one participant, there was a general lack of visual interest in participants' designs. It was visually uninteresting due to a lack of variety of techniques and contrasting elements. On the other hand, participant 9 demonstrated significant improvement in realising visual interest by combining design elements and techniques in a creative and novel way. Participant 21's exploratory drawing in the end-of-year-exam (figure 4.21) exemplified sustained transfer of knowledge without significant improvement since the evaluation in the project, discussed previously, although it was already fairly good, as indicated in the earlier discussion.

4.5 Conclusions and recommendations

The findings of this research will now be concluded. The findings for each research question will be summarised separately with recommendations for the improvement of the tutorial.

4.5.1 Research question 1: What are the implications of the participants' reaction to the tutorial for the possible improvement thereof?

Sub-question 1 Were the participants satisfied/dissatisfied with the tutorial?

Sub-question 2: What was the perceived usefulness of the tutorial?

Sub-question 3: What about the tutorial were the participants dissatisfied with?

The conclusion derived at through analysing the data in support of answering research question 1 is summarised below:

- Did the participants like and enjoy the training?
- Was it easy?
- Were the participants comfortable using the tutorial?
- Did participants understand how to work with the tutorial?
- Did the participants consider the training relevant?

- What was the perceived practicality and potential for applying the knowledge and learning?
- Was it good use of participants' time?
- Which aspects of the tutorial did participants not like?

In order to maximise users' satisfaction, and therefore their motivation to use the tutorial participants' dissatisfaction with the some aspects of the tutorial should be taken into consideration. The tutorial should:

- be shortened, by breaking it up in separate sections that could be worked through independent of each other;
- be accessed in alternative ways; and
- include navigational options.

Despite participants' negative reactions about the time it took to complete the tutorial, their motivation to work through the tutorial implied their overall positive feelings about the tutorial. This indicated that the participants were motivated and felt positive about the design tasks in the module. They thought that the tutorial was easy and enjoyable to use. Except for some negative responses towards navigational aspects, their responses indicated their general satisfaction with the programming aspects of the tutorial. The findings in research question 1 indicated the following:

- possible limitations of the tutorial;
- possible limitations in the delivery of the tutorial; and
- participants' motivational levels in using the tutorial.

4.5.2 Research question 2: What are the implications of participants' retention of knowledge for possible improvement of the tutorial?

Sub-question 1: What knowledge was retained immediately after exposure to the tutorial?

Sub-question 2: What knowledge was retained after some time?

In their schemas of design principles and design elements, I investigated the data informing me of:

- how well the drawings revealed the design elements and techniques used to realise design principles in the schemas as well as in the designs;
- sufficient clarity in the schemas; and
- sufficient visual interest in the designs.

The conclusion derived at answering research question 2, which was supported by analysing the data of immediate retention and learning after some time, is presented here. The findings indicate significant correlations between learning on the immediate retention level and that of learning after some time pertaining to the participants' understanding of the constructs of the domain under discussion:

- participants knew the design principles fairly well, except for the concept "balance", which seemed to be problematic for some in both stages;
- participants knew most of the design elements fairly well, except for "texture" which seemed to be problematic for some on the level of learning after a period of time;
- knowledge of how design techniques are implemented to manipulate elements and arrangements on the format started to emerge in the visual analysis as well as in the drawings at the level of learning after some time, which demonstrated an improvement from the level of immediate retention when knowledge seemed to be very poor; and
- there seemed visible evidence of the tutorial's contribution in immediate retention of knowledge as well as in learning after some time.

The implications of the above findings for improving the tutorial can be summarised as follows:

- the principle balance needs clarification with more explicit explanations and examples
- the element texture needs clarification, more explicit examples;
- explicit explanations and examples about technique should be included;
- explicit explanations and examples about visual interest should be included; and
- interactive exercises/experiments with techniques revealing explicit visual effects in order to make students aware of the concept “visual interest” should be included.

4.5.3 Research question 3: What are the implications of participants’ behaviour/transfer for possible improvement of the tutorial?

Sub-question 1: What knowledge was transferred to participants’ designs for their projects?

Sub-question 2: What was the sustained change in behaviour in the end-of-year examination?

The conclusion to research question 3 was:

- All participants managed to reveal the design principles and elements with sufficient clearly, indicating that transfer of knowledge regarding principles and elements have taken place sufficiently in order to change participant's behaviour. This change in

behaviour was sustained after a period of time during the examinations.

- Some participants improved significantly in transferring their knowledge of design techniques from the first assessment on level 3 to the second assessment, while some participants who already performed well in the first assessment, did not improve much.
- Some participants' could represent their ideas well while some still had not achieved the necessary drawing skills.
- Most participants did not achieve creating visual interest well in the first assessment on level 3. However, in the second assessment significant improvement in the transfer of this skill was evident in the drawings of some participants.

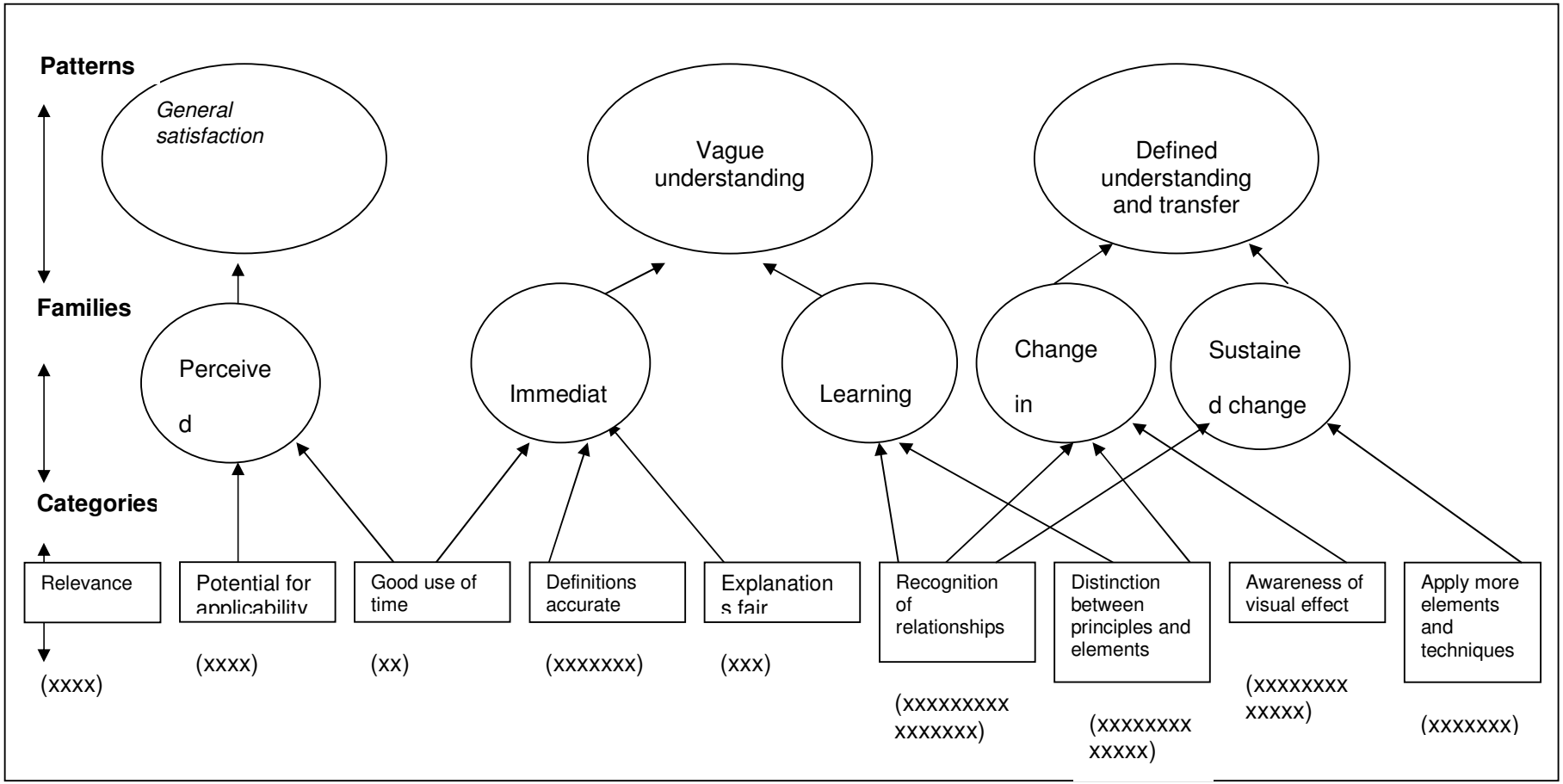
The implications for improving the effectiveness of the tutorial are the following:

- students should be encouraged to revisit the tutorial more often once interaction is built in;
- an interactive visual analysis exercises should be included to give students greater exposure to this type of thinking; and
- the lecturer should ensure that the learning curve continue also for students who already perform well in level 2 by individualised enrichment and challenges – develop an advanced tutorial.

From the conclusion of this research I could group the tendencies occurring into segments of patterns, families of concepts and categories of learning, as illustrated in figure 4.22.

Figure 4.22 Segments of patterns, families and categories (see next page)

Figure 4.22 Segments of patterns, families and categories



5.1 Introduction

In summary I will discuss the salient points of this study pertaining to the findings and the research methodology applied.

5.1.1 The findings

The findings of this study revealed that participants demonstrated learning of the design constructs specific to the domain of aesthetics in segments of patterns, families and categories (figure 4.22). These segments were evident in the three levels of learning evaluated for the purpose of this study.

5.1.1.1 Level 1: Reaction

- Participants were in general satisfied with the tutorial. Despite participants' negative reaction about the time it took to open the tutorial from the Internet, they were motivated to work through the tutorial, implying their overall positive feelings about the tutorial. This was an indication of the participants' motivation and positive attitude towards the design tasks in the module. They enjoyed the visual images in the tutorial and also found the tutorial easy to use, which indicated their satisfaction with the programming of the tutorial.

- The semi-structured interviews confirmed what was found in the literature, i.e. despite negative responses to other aspects of the tutorial, participants considered the relevance of the tutorial so important that they would revisit and reuse it (Clark, n.d.) - in the rest of the module as well as for other modules in the design and technology programme.

5.1.1.2 Level 2: Learning

The data gathered from the exercise conducted immediately after the intervention supported the argument that participants demonstrated immediate retention of some of the design principles; that they retained knowledge of design elements to a lesser degree; and showed very little evidence of understanding the use of techniques to realise design principles.

After a period of time students wrote a test requiring of them to do visual analyses of existing designs as well as visualising their understanding of particular aesthetic constructs. The data thus generated indicated varying degrees of ability to distinguish between the constructs of design principles and elements in responses to questions pertaining to visual analysis. Confusion between design principles and elements was apparent. It became evident that some participants did not grasp the intricate interplay between design principles, design elements and techniques in a design. However, some participants' responses after a period of time indicated an emerging increase in sensitivity for detail. This could be seen in their

use of appropriate terminology; detailed references to specific elements and techniques in the design, and insightful explanations of how techniques were used in establishing design principles.

5.1.1.3 Level 3: Transfer

The findings of this study indicated that participants retained their knowledge obtained in level 2. They were able to differentiate between the various design elements and could draw from their previous experiences in order to develop better conceptual understanding of the constructs specific to the domain of aesthetics in design environments.

The representational drawings in the project indicated that although participants retained knowledge of the design principles and design elements fairly well, they failed to add much visual interest to their designs because of a lack of contrast and anomaly that usually prevent visual boredom on the side of the viewer (Wong, 1993).

5.1.2 Research methodology

The research methodology decided upon for this study, as well as the qualitative nature of the study had its own inherent advantages and limitations as summarised below. The way these advantages and disadvantages impacted on the findings of this study will later be discussed in more detail.

5.1.2.1 Qualitative nature of the research

The qualitative nature of the data gathered in this case study, approached from an interpretive perspective, had the advantage of providing me with rich data (Cohen *et al.*, 2000). Being researcher and lecturer at the same time, however, inherently posed the danger of bias. For this reason multiple data gathering instruments had to be implemented to validate the findings.

5.1.2.2 Development research

The two aims of development research, namely contributing to the improvement of instructional design and to the formulation of theory, were achieved and partially achieved in this research (Van den Akker, 1999). It was possible to contribute to the improvement of the tutorial. However it was not possible to generate theory due to limitations inherent to the Kirkpatrick (1994) model implemented for gathering data. These limitations will later be discussed in detail.

5.1.2.3 Kirkpatrick's model for evaluating learning

Kirkpatrick's four level model (Kirkpatrick, 1994) provided me with a structure that simplified the complex task of evaluating the learning that took place. In addition it enabled me to analyse data in a systematic way. However, I found the model over-simplified issues and therefore, I used Alliger's augmented model (Alliger *et al.*, 1997) in addition to Kirkpatrick's model for evaluating learning. The augmented model provided sub-levels for categorising data into more refined categories. However, inherent to the four level model for evaluating learning, however, I experienced three major limitations, namely (1) an over-simplification of learning and (2) only causal linkages between the levels could be inferred and (3) emphasis on the outcomes of learning only and no providing for the processes involved in learning.

5.2 Relation of the findings to the literature and theory

Subsequently I will summarise the relation of the main findings of this study with the literature and theory surveyed for this study. The three categories of literature surveyed, CAL, levels of learning and design studies, will be related to the main findings in the study.

5.2.1 Computer assisted learning (CAL) theories and the findings of the study

Aspects of the findings as described and discussed in chapter 4, for which support could be found in the literature pertaining to CAL, namely theories about CAL in technology education, the suitability of Microsoft PowerPoint™ and tutorials, will be highlighted.

5.2.1.1 CAL in technology education

Atkinson (1998) proclaimed that CAL applied in technology education programmes could stimulate technological activity. In this study, it was evident that the tutorial stimulated the design activity. It required students to engage in investigating[40] existing designs in order to relate them to the constructs in question, which were reflected in participants' responses to all the data generating strategies implemented on level 2 and 3 (see chapter 4).

Atkinson is further of the opinion that CAL could bring design contexts into the classroom (Atkinson, 1998). The tutorial visualised a variety of design contexts reflected in the different product designs described and explained in terms of aesthetics. Evidence of its impact on participants' learning was found in their drawings in the test (Addendum 8) that reflected their learning after a period of time. The similarities between their schemas and the images in the tutorial were significant. The drawings of the participants were also an indication of the

[40] Investigating is the first step in the design process, prescribed by the *RNCS* (2002), as one of the technological processes in technological activity.

potential value of the computer for stimulating graphics and modelling activities (Atkinson, 1998).

In chapters 1 and 2 I explained that the purpose of the tutorial was to instruct and reveal information. Atkinson also describes instruction and revelation of information as one of the functions of computer assisted learning in design and technology contexts (Atkinson, 1998). Participants' utility judgements in the questionnaire indicated that they perceived the tutorial as useful to learning aesthetics (Addendum 2), implying that they perceived it as a useful source of information and instruction.

Atkinson (1998) indicated that computer assisted learning support material should be self-paced and self-accessed, and function as a tool to facilitate learning at the point of need in order to be effective as educational tool. The tutorial was not completely self-paced. Some participants indicated their frustration with its lack of sufficient navigational options in the questionnaire, which lengthened the time it took to work through it. Participants could access the tutorial through the Internet. In the questionnaire some participants indicated frustration at the slowness of opening the tutorial from the Internet whilst others expressed their satisfaction with the ease of access. One of the aspects raised in the questionnaire (Addendum 1) and Interview (addendum 3) indicated that learners would like to have help at the point of need while working on the tutorial. This reaction suggested to me that the effectiveness of the tutorial could be improved by including interactivity.

5.2.1.2 Suitability of Microsoft PowerPoint™ as platform

The advantages and disadvantages of Microsoft PowerPoint™ have been described for a long time. Participants of this study expressed their satisfaction with the ease of use of the tutorial in the questionnaire (Addendum 2). Montgomery (2004) promotes the use of Microsoft PowerPoint ™ in educational contexts because of the advantages of linearity that contributes to the ease of use.

The ability of Microsoft PowerPoint™ to be programmed in an interactive tool also has pedagogical advantages (Alessi & Trollip, 2001). The tutorial has one branch linking to a website on the Internet. When questioned on the usefulness of this link, participants indicated in the semi-structured interview (Addendum 3) that they did not have time to follow the link, but would like to examine it during a separate session. The implication is that the branching will only be useful when the tutorial is divided into separate sections in order to limit the amount of time or if it is completely self-paced.

Critics of Microsoft PowerPoint™ warn of the dangers of this platform being boring to viewers. Participants' responses to the questionnaire indicated that they enjoyed the tutorial and experienced the graphics and examples as exciting and relevant. No indication of boredom could be found in their reactions to the tutorial.

5.2.1.3 Tutorials

Literature indicated many different types of learning that is supported by tutorials, e.g. immediate retention, learning after a period of time and transfer of knowledge in new situations (De Villiers, 2002; Kirkpatrick, 1994). Much evidence of these types of learning was demonstrated in the various data generating strategies described in chapter 4. As was suggested earlier, evidence of inferred causal linkages between intervening with the tutorial could be found in the drawings in the test (see figures 4.1 – 4.15).

Tutorials have also been described as instrumental to learning strategies of individuals in which a particular set of skills are organised and used in order to learn its content or accomplish tasks (Schumaker *et al*., 1984). The findings presented in chapter 4 did not portray evidence of the ways in which participants actually organised the content of the tutorial; due to the focus on the outcomes of the intervention and not on the process of learning.

5.2.2 Levels of learning

The relation between the literature as the basis of the evaluation of the three levels of learning in this study, reaction, learning and behaviour, from Kirkpatrick's model of evaluating learning (Kirkpatrick, 1994), and the findings of this research will subsequently be summarised.

5.2.2.1 Level 1: Reaction

One of Kirkpatrick's theories is that the initial reaction to instruction will influence quality and quantity of learning. He acknowledges that a positive reaction does not guarantee learning, but argues that a negative reaction reduces learning (Kirkpatrick, 1994). Schumaker (1984) also proclaims that tutorials should be presented in such a way that learners are motivated and enjoy what they are doing in order for learning to be effective. Participants' responses to the questionnaire (Addendum 1) and interviews (Addendum 3) in this research indicated that they were positive towards the tutorial which motivated them sufficiently to work through the tutorial for at least four hours (level 1) and to complete the exercise (Addendum 6) on level 2 at the end. However, no evidence could be found of the causal linkage between the positive reaction and the quality and quantity of learning.

Alliger (1997) explained that participants express feelings of satisfaction by indicating how much they like interventions in the form of affective comments. Participants also indicate their perceived usefulness of the interventions through utility judgements. Affective responses to and utility judgments in the responses to the questionnaire (Addendum 2) provided much useful information pertaining to participants' likes and dislikes of aspects of the tutorial.

5.2.2.2 Level 2: Learning

Kirkpatrick describes learning as a change taking place on an intellectual level (1994). Clementz (2002) interprets an increase in knowledge as the amount of content learned and concepts and principles mastered. Skills are seen as the improvement of performance and technique. The findings of this research presented in chapter 4 indicated an increase in knowledge of constructs as well as the skills demonstrated on level 2 in the visual analyses, as well as the drawings of the participants in the sub-level of immediate retention, through the exercise and test. On level 2 the following changes on the intellectual level was evident in participants' drawings in the test, after a period of time, indicating the following:

- Some participants' schemas were very similar to the images in the relevant slides in the tutorial, which indicated "memory traces of shapes from past experiences" (Arnheim, 1954, p.5).
- Participants, whose drawings resembled the examples in the tutorial, did not necessarily have better conceptual understanding of the constructs tested than those whose drawings showed no resemblance.
- Schemas not resembling the examples in the tutorial closely, but that realised the design principle in question by using other design elements, techniques and arrangements on the format, demonstrated intent as well as conceptual understanding.

5.2.2.3 Level 3: Behaviour

Kirkpatrick (1994) describes evaluation of behaviour as evaluation of the transfer of knowledge, skills and attitudes from one situation to another. Evidence of the transfer of knowledge and skills in the domain of aesthetics acquired through intervening with the tutorial and retained and sustained on level 2 was transferred to new situations in level 3. Participants' behaviour was demonstrated in the projects and end-of-year examination discussed in chapter 4. The change in behaviour was evident in the following segments of patterns that emerged (see figure 4.22):

- Participants revealed the design principles and elements clearly, indicating transfer of

knowledge regarding principles and elements. This transfer of knowledge was sustained after a period of time during the examinations.

- Some participants improved significantly in transferring their knowledge of design techniques from the first assessment on level 3 to the second assessment (figure 4.20), while some participants who already performed well in the first assessment, did not improve much (figure 4.18 and 4.21).
- Some participants' drawing skills have developed such that they could represent their ideas well (figure 4.20) while others still had not achieved the necessary change in behaviour in this respect (figure 4.19).
- Most participants did not achieve creating visual interest well in the first assessment on level 3, namely the projects. However, in the second assessment in the examination, I found significant evidence of development in the drawings of some participants, which not only enabled them to represent their ideas better, but also enabled them to include visual interest better (figure 4.20).

Kirkpatrick (1994) is of the opinion that it is impossible to predict when change in behaviour will take place. Predicting when change takes place focuses the attention on the process of learning and not on the outcome, which contradicts the inherent focus of Kirkpatrick's model, namely the outcomes of interventions (Bates, 2004). It was evident in this study that when evaluating the levels of learning, it does not allow for studying the process but only the outcomes (performance) of the participants, which I consider as one of the limitations of the study.

In this section it has been shown how the findings of this study correlated with Kirkpatrick's (1994) theory of evaluating the levels of learning and which areas in his theory were not substantiated by evidence in the findings. I will subsequently highlight evidence of correlations between the findings of the study and that of theories about design studies pertaining to aesthetics.

5.2.3 Design studies

Correlations and anomalies between the findings of this study and the main points in the literature surveyed, referring to drawing as a cognitive tool, will now be discussed.

5.2.3.1 Drawing as a cognitive tool

Garner's (1994) report on studies of the role of drawing in design and technology education programmes revealed drawing as a powerful promotion of the cognitive process in design and technology programmes. Drawing also played an important role in developing higher

order thinking skills. Analysing levels 2 and 3 of learning in this study revealed that participants' drawings involved the following cognitive activities that correlated with Garner's theory of the role of drawing in technology classrooms in cognitive development of learners:

- retention of knowledge (indicated on level 2);
- application of knowledge (indicated on level 2 and 3);
- analytical abilities including decision making, evaluating abilities and critical abilities (indicated on level 3); and the
- transfer of knowledge (indicated on level 3).

Atkinson (1998) found in her research done on novice designers in technology classrooms that those learners who produced the best drawings, also generated higher quality of conceptual ideas. I found evidence correlating to Atkinson's (1998) theory in the drawings of the participants in this study. Participants 9 and 21, who produced better drawings (figures 4.20 and 4.21) than participant 14 on level 3 (figure 4.19), also managed to generate higher quality of visual interest in their designs.

Arnheim's theory that new images come into contact with memory traces of shapes from past experiences that are similar (Arnheim, 1954), was confirmed by the findings of this study. The close resemblance of participants' schemas of design principles, elements and techniques with those of the images in the tutorial, indicated how traces of shapes and other elements seen in these images influenced participants' new drawings (figures 4.1 – 4.15).

Tversky's notion of drawing as a cognitive tool that can reveal thought and conceptual understanding by using standard segments and elements in numerous different combinations (Tversky, 1999), supported the above theories. The drawings of the participants (figures 4.16 – 4.21) in this study revealed evidence of how they applied their newly acquired knowledge of visualising their ideas for lamp designs on level 3.

It has also been shown that exercises and the process of drawing development enhanced visual understanding that broadened the "visual library" of design elements, techniques, details and potential applications (Anderson, 1998). The outcome of this study, indicating that the improvement in the quality of the drawings of some participants in the examination (level 3), correlated with Andersons theory, namely that repeated drawing exercise and experience led to more detailed drawings. Some participants' drawings revealed a marked increase in attention to detail by applying a variety of elements (figure 4.20) not applied in drawings in the project (figure 4.16) or earlier drawings in the test (figures 4.1 and 4.7). It

was found that it was this increased attention to detail that improved the visual interest of the participant's designs (see chapter 4).

In addition the data generated by questions in the exercise and in the test (level 2), indicated that repetitive exposure to the activity of visual analysis improved from vagueness to specifics and recognition of detail (see figure 4.22). The findings reported on in chapter 4 also indicated that the tutorial served as stimulus to recognising and identifying constructs applicable to designs in the exercise with questions pertaining to visual analysis. This led to participants' understanding of concepts in aesthetics, which correlates with what Davies (2000) found in activities pertaining to the improvement of observation skills, namely that in order to achieve conceptual understanding, students have to be skilled in observation. Analytical thinking and the application of knowledge and skills in subsequent drawings can improve observations skills (Davies, 2000).

In the subsequent section, I will highlight the role the research methodology played in answering the research questions.

5.3 The research methodology and its impact on the study

In order to establish the role of the research methodology selected for this study, in answering the research questions, the nature of the study and the aims of the study will be related to the findings of the research.

5.3.1 The nature of the study

The qualitative nature of this case study suited the chosen research methodology well. The inherent flexibility of qualitative research allowed me to adapt the sample size, the pace and the scope of the research to the research process according to changes in circumstances. The number of participants, who initially indicated their availability till the end of the research, kept on changing until the end of the examination, when only three students were in fact available to take part. The pace at which the class' project developed was different for different students, due to events such as a lack of commitment by some students to complete in time, forgetfulness and illness. These events complicated the control of the pace at which the research was conducted.

The qualitative nature of the research data enabled me to make rich and thick descriptions in order to portray the complexities involved in the learning of the aesthetic domain-specific constructs accurately. The multiple strategies implemented for evaluating the different levels of learning contributed to the richness of the data, while at the same time served as tool for

crystallisation of the findings. In addition it allowed me to blend descriptions of the learning context with the analysis thereof and highlighted specific events that were relevant to the case.

This study falls in the category of social responsible development research, implementing evaluation strategies to gather and interpret data.

5.3.2 The aims of social responsible development research

The study had two aims, namely interpretive and development. Interpretive goals portray how education works by describing and interpreting phenomena related to teaching, learning, performance, etc. (Reeves, 2000). In this the interpretive aims were met by:

- portraying which aspects of the constructs specific to the domain of aesthetics were learned (see table 5.1); and
- establishing the role of the tutorial in learning aesthetic constructs (see table 5.2).

Development goals refer to the dual objectives of (1) developing creative approaches to solving human teaching, learning and performance problems, and (2) constructing a body of design principles[41] that can guide future development efforts (Reeves, 2000).

Table 5.1 summarises the interpretation of the data in this study, meeting the interpretive goal of the approach to this study.

Table 5.1 Interpretation of the data

Information sought	**Information found and interpreted**
Level 1 • Did the participants consider the training relevant? • What was the perceived practicality and potential for applying the knowledge and learning? • Was it worth their while?	Participants indicated that they **perceived** the tutorial as **useful** due to its • relevance to the module; • usefulness to other modules; and • practical applicability. I learned from the responses to the questionnaire and semi-structured interviews that participants perceived the tutorial as useful, and, therefore, considered their time well spent.

[41] "Design principles" here refers to principles pertaining to the design of instruction and instructional material (Van den Akker, 1999) and not to the construct of aesthetic design principles.

Information sought	Information found and interpreted
Level 2: • What did participants learn about the design principles? • What did they learn about the design elements? • What techniques could they identify and relate to the principles and elements?	Participants' responses to the **visual analysis** questions in the test indicated the following pertaining to their retention of knowledge after a period of time: • they could not differentiate well between design principles and elements; • they could identify most design elements; • the design principle "balance" was not yet understood yet; • there was an emerging increase in sensitivity to detail; • some understanding of the purposeful use of techniques to create specific principles was emerging; and • they could transfer some knowledge from 2-D designs to 3-D objects. Participants' responses to the **drawing** questions in the test indicated the following pertaining to their retention of knowledge after a period of time: • all the participants knew the design principles; • not everyone recalled the design element "visual texture"; • in most cases participants recalled a specific design in the tutorial illustrating the particular design principle/element in question.
Level 3: • How well did the drawings reveal the design elements and techniques used to realise design principles?	The conclusion to research question 3 was: • All participants managed to reveal the design principles and elements with sufficient clarity, indicating that transfer of knowledge regarding principles and elements has taken place sufficiently in order to change participant's behaviour. This change in behaviour was sustained after a period of time during the examinations.
• Was there sufficient clarity? • How well did it represent the idea?	Some participants improved significantly in transferring their knowledge of design techniques from the first assessment on level 3 to the second assessment, while some participants who already performed well in the first assessment, did not improve much.
• Was there sufficient visual interest created through variety?	• Some participants could represent their ideas well while some still had not achieved the necessary drawing skills. • Most participants did not achieve creating visual interest well in the first assessment on level 3. However, in the second assessment significant improvement in the transfer of this skill was evident in the drawings of some participants.

The interpretive aim of the study was to describe and interpret the extent to which the tutorial under discussion contributed to students' learning of the constructs of aesthetics in a technological context. The information gathered for this purpose was used to indicate the adequacy of the tutorial in achieving the learning outcomes of the module (see chapter 3). The outcome of the module relevant to this study was to demonstrate knowledge, transfer and application of aesthetics, namely design principles, elements and techniques, as well as the extent to which achievement was established and validated by this study. These are summarised in table 5. 3

Table 5.2 summarises the role of the tutorial in the realisation of the module's outcomes.

Table 5.2 Role of the tutorial in the realisation of the module's outcomes

Research question 1: What are the implications of the participants' reaction to the tutorial with regard to the possible improvement thereof?	
Outcome of the module	**Cognitive and affective activities indicating the outcomes**
use contextually integrated learning support material that • is instrumental in learning • students perceive as useful • create a positive attitude in students regarding the learning support material and the module	• affective reactions in response to the questionnaire indicating participants' general satisfaction with the tutorial • utility judgements in response to the questionnaire indicating the perceived usefulness of the tutorial are instrumental to participants' learning of the constructs
Role of the tutorial established Evidence of similarities between explanatory text in the tutorial and that in the responses of participants in the exercise and the test pertaining to visual analysis, indicated a direct link between the content of the tutorial and what was learned	
Research question 2: What are the implications of the participants' retention of knowledge with regard to the possible improvement of the tutorial?	
Outcome of the module	**Cognitive activities indicating the outcomes**
• investigating existing designs; analysing existing designs • drawing ideas on paper • applying graphic skills: using colour, rendering techniques and three-dimensional drawings; • choosing the best solution	• **visual analysis** in the exercise and in the test • indicating immediate retention and learning after a period of time • **drawing** in the test indicating learning after a period of time
Role of the tutorial established Schemas in the test indicated easily discernable similarities between existing designs in the tutorial and participants' schemas. Similarities in participants' final representational drawings in the project and development drawings in the examination were not so easily discernable. However, the evidence of learning transferred to the project and examination confirmed Arnheim's (1954) theory that new images come into contact with memory traces of shapes from past experiences that are similar and, therefore, I inferred that the intervention with the tutorial had an ongoing effect on participants' learning on level 2 and on 3 summarised below.	
Research question 3: What are the implications of the participants' behaviour/transfer with regard to the possible improvement of the tutorial?	
Outcome of the module	**Cognitive activities indicating the outcomes**
• drawing ideas on paper • applying graphic skills: using colour, rendering techniques and three-dimensional drawings; • choosing the best solution[42] preparing final representational drawings	• representational drawings in the project indicating change in behaviour (transfer of learning) • development drawings the examination indicated sustained change in behaviour

The development goals of this study, namely

- developing creative approaches to solving human teaching, learning and performance problems; and
- generating, articulating and testing design principles (Van den Akker, 1999)

[42] Representational drawings in the project were the outcome of a process of choosing the best solution and did not indicate the choosing process.

were partially met. The first goal namely was met by creating a set of suggestions of how to improve the tutorial. Table 5.3 summarises the suggestions. The second goal was not met, due to the limitations inherent to qualitative research, as discussed in 5.4.1.

Table 5.3 Useful solutions for improving the tutorial suggested by the data

What to keep	What to change
• The way it works. • Asynchronicity. • Examples in colour. • Organisation of material. • Understandable language. • Good layout. • Practicality.	• Enlarge pictures. • Find a quicker way to open from the Internet – alternatively provide tutorial on CD. • Add interactivity providing help with the exercise. • Make distinction between design principles and design elements clearer by changing the titles or adding screens.
What to keep	**What to change**
• Usefulness for other modules. • Ease of use. • Accessibilty. • Visual appeal of graphics used.	• Deliver the tutorial earlier in the year in the module on graphic design. • Check protocol thoroughly for inconsistency of font sizes. • Re-programme allowing users to exit the tutorial sooner. • Shorten the tutorial by providing material in separate sections. • Include a menu with navigation buttons. • Add more examples, on which the differentiation between the design elements is clearly indicated.

Table 5.4 indicated that this study provided me with suggestions useful for a variety of improvements of the tutorial, thus complying with the purpose of social responsible research (Van den Akker, 1999), namely to improve instructional design practice, development and the evaluation thereof (Van den Akker, 1999). In addition, the concern in social responsible research with the practical uses of the research findings and with understanding “how” instructional technology improves education was partially fulfilled in this study. In chapter 4 the visual similarities between designs in the tutorial and the drawings of some participants were shown and reported on. It can thus be said that the “power of the image” (Van den Akker, 1999) brought by the electronic medium contributed directly to learning. This retention of visual material was in later stages of the research transferred to new design contexts.

From the conclusions and recommendations of this study, I developed the following theory pertaining to the design and evaluation of electronic tutorials for the domain of aesthetics.

General principles formulated: visual and verbal reference to the constructs and segments of the constructs should be done explicitly and repeatedly in tutorials. Ways to reinforce students' verbal referencing could include interactive activities as part of the tutorial in order to provide help to users whenever it may be needed.
Demonstration of change in behaviour (transfer of knowledge about constructs) in level 2 should not be interpreted as permanent change occurring early in the learning process unless sustained change in level 3 is also evident.

5.4 Limitations of the study

Limitations of this study, as emerging from the research findings, are discussed by referring to the disadvantages of the type of research implemented, the researcher's effect and the difficulties experienced in the research.

5.4.1 Disadvantages of qualitative research

The disadvantage of this study can be ascribed to its qualitative nature, which limited this research's ability to lead to generalisation (Van den Akker, 1999). Readers need to be encouraged to make their own attempts at exploring the potential transfer of the findings of this research to theoretical propositions in relation to their own context (Van den Akker, 1999).

5.4.2 Researcher's effect

In addition to its failure to generalize, I experienced my integral involvement (researcher effect) in this case study problematic due to the potential bias stemming from being the researcher as well as lecturer (Miles & Huberman, 1984). The potential dangers that had to be acknowledged were the following:

- my presence in the computer laboratory could change the participants' behaviour, e.g. being more nervous and, therefore, not performing as well as they should;
- my becoming personally involved with participants;
- my own artistic biases influencing objective analysis and conclusions;
- my competence as novice researcher pertaining to content analysis and visual analyser of aesthetics; and
- participant's inability to express themselves clearly and, therefore, the danger of misinterpreting reactions could be included in the final write-up.

5.4.3 Difficulties in the research

I experienced the evaluation of learning and transfer in this study to be more difficult and time consuming than the measurement of reactions, which is confirmed by Kirkpatrick (Kirkpatrick, 1994). The reasons for this are closely linked to (1) the complexity of the criterion set for the activities of visual analysis and drawing and (2) the compound way in which constructs appropriate to the domain can manifest in designs (Tversky, 1999), explained in section 4.7.3. Another difficulty was discerning whether drawings were evidence of memory traces (Arnheim, 1954) or whether intent and conceptual understanding were also imbedded (Tversky, 1999).

5.4.4 Future research

I encountered many unanswered questions pertaining to the process of learning that need to be examined through other means than allowed by the Kirkpatrick model (Kirkpatrick, 1994). The reason for this is the focus of the model on outcomes of instructions only and not on the process of learning:

- What are the reasons for the retention of some design principles being better than others?
- What are the reasons for some design principles being identified easier than others?
- What is the effect of the change in the behaviour and sustained performance of students peaking early in the module, but not improving on level 3?
- What are the reasons for the participants' difficulties in distinguishing between concepts of design principles and elements?
- To what extent do correlations exist between performance in visual analysis and the visualising of aesthetic constructs in drawings?

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Addendum 1 Questionnaire

Questionnaire: Tutorial on Design Theory "Design in Action" **Vraelys: Tutoriaal oor Ontwerpteorie "Design in Action"**
Question 1/ Vraag 1 What did you like most about the tutorial?/Wat omtrent die tutoriaal het jy die meeste van gehou?
Response/Respons
Question 2/Vraag 2 What would you have liked different in the tutorial?/Wat omtrent die tutorial sou jy anders wou hê?
Response/Respons
Question 3/Vraag 3: What did you like least about the tutorial?/Wat omtrent die tutorial het jy minste gehou?
Response/Respons
Question 4/Vraag 4 Did you understand the language and terminology used in the tutorial?/Kon jy die taal en die terminologie in die tutoriaal gebruik, verstaan?
Response/Respons
Question 5/ Vraag 5 Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design?/Sou jy dit verkies om blootstelling aan hierdie tutoriaal te gehad het aan die begin van die module oor grafiese ontwerp?
Response/Respons
Question 6/ Vraag 6 Which aspect of the design theory did you **understand the least before** working through the tutorial?/Watter aspek van die ontwerpteorie het jy die **minste verstaan voordat** jy deur die tutoriaal gewerk het?
Response/Respons
Question 7/ Vraag 7 Which aspect of the design theory did you **understand best before** covering the tutorial?/Watter aspek van die ontwerpteorie het jy die **meeste verstaan voordat** jy deur die tutoriaal gewerk het?
Response/Respons
Question 8/Vraag 8 Which aspect of the design theory did you **learn best as a result of exposure** to the tutorial?/Van watter aspek van die ontwerpteorie het jy die **meeste geleer deur jou blootstelling** aan die tutoriaal?
Response/Respons
Question 9/Vraag 9 Which aspect of the design theory did you **learn least as a result of exposure** to the tutorial?/Van watter aspek van die ontwerpteorie het jy die **minste geleer deur jou blootstelling** aan die tutoriaal?
Response/Respons
Question 10/Vraag 10 Did you manage to complete the exercise in time?/Kon jy klaarkry met die oefening in die gegewe tyd?
Response/Respons

Addendum 2 Classes of reactions: responses to the questionnaire

1. Affective reaction to direct questions		
Participant	**Positive reaction**	**Negative reaction**
Participant 9		**Question 4:** "Could you understand the language and terminology used in the tutorial?" **Reply:** "Not clearly" **Question 11:** "Did you manage to complete the tutorial and the exercise in time? If not, indicate how many questions did you manage to complete" **Reply:** "*No"*
Participant 14	**Question 4:** "Could you understand the language and terminology used in the tutorial?" **Reply:** "Ja" translated *Yes* **Question 11:** "Did you manage to complete the tutorial and the exercise in time? If not, indicate how many questions did you manage to complete" **Reply**: "Ja, dit het sowat 4 ure se harde werk gekos" translated *Yes, it took approximately 4 hours' hard work*	
Participant 21	**Question 4:** "Did you manage to complete the tutorial and the exercise in time? If not, indicate how many questions did you manage to complete" **Reply**: "I completed all of them in my own time, but was time consuming, maybe less designs to explain" **Question 11:** "Could you understand the language and terminology used in the tutorial?" **Reply:** *"Yes, very straight forward and easily understood. Maybe a little more pictures to show*	

Addendum 2 (cont)

2. Affective reaction to indirect questions		
Participant	**Positive reaction**	**Negative reaction**
Participant 9	**Question 1:** "What did you like **most** about the tutorial?" **Reply:** "Dit was maklik om meet te werk en ek kon dit op my eie tyd doen" translated *It is easy to work with and you can work at your own pace*	**Question 2:** "What would you have **liked different** in the tutorial?" **Reply:** *"For the pictures to be enlarged"* **Question 3:** "What did you like **least** about the programming" **Reply:** "It is too slow to open from the site"
Participant 14	**Question 1:** "What did you like **most** about the tutorial?" **Reply:** "Dit was baie "user-friendly", daar is niks rêrig snaaks aan die program nie." translated *It was very user-friendly, there is nothing really strange to the program*	**Question 2:** "What would you have **liked different** in the tutorial?" **Reply:** "Die internet links vat 'n rukkie om oop te maak" translated *The Internet links take a while to open* ***Question 3:*** What did you like **least** about the tutorial? **Reply:** "Daar was nie rêrig iets nie" translated There really wasn't anything
Participant 21	**Question:** "What did you like **most** about the tutorial?" **Reply:** *"It was easily accessible and easy to work with"*	**Question:** "What would you have **liked different** in the tutorial?" **Reply:** *"Maybe the fonts on some parts of the program. Some of the writing was too big or too small"* **Question:** "What did you like **least** in the tutorial?" **Reply:** *"The organisation is a little unorganised"*

3. Utility judgements in response to the questionnaire		
Participant	**Value of particular slides**	**Relevance of the tutorial**
Participant 9	**Question 9:** Of which aspect of the design theory in the tutorial did you **understand** the **least?** **Reply:** "*Nothing*" **Question 12:** Of which aspect of the design theory did you **learn the most** through the tutorial? **Reply:** *"Balance and illusion of motion"*	**Question 5:** "Would you **prefer** to have had exposure to this tutorial at the beginning of your module on graphic design?" **Reply:** *"Yes – because its easier to understand visual information"*

Addendum 2 (cont)

Participant 14	**Question 9: Of which aspect of the design theory in the tutorial did you understand the least?** **Reply: "Niks"** **Question 12: Of which aspect of the design theory did you learn the most through the tutorial?** **Reply:** **"Alles"** **translated** **Everything**	**Question 5: "Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design?"** **Reply: "Nee, almal wat CIL gehad het in die 1ste jaar hoort te weet hoe om die program te werk"** **translated** **No, everyone who had CIL in the first year, ought to know hoe to work the program**

3. Utility judgements in response to the questionnaire		
Participant	**Value of particular slides**	**Relevance of the tutorial**
Participant 21	**Question 9:** Of which aspect of the design theory in the tutorial did you **understand the least?** **Reply:** *"Unity and how to achieve it in a design"* **Question 12:** Of which aspect of the design theory did you **learn the most** through the tutorial? **Reply:** "The design elements and principles. Useful"	"Would you prefer to have had exposure to this tutorial at the beginning of your module on graphic design?" **Reply:** *"Yes, maybe a lesson concentrating on this, maybe also not on own time but, during class time"*

Addendum 3 The semi-structured interview

Interview: Tutorial on Design Theory "Design in Action" **Onderhoud: Tutoriaal oor Ontwerpteorie "Design in Action"**
Question 1: "Did the fact that the tutorial took such a long time to work through cause you to rush through the exercise?
Question 2: Do you think that some parts of the content were covered in more detail than others? If so, which ones?
Question 3: Were there any specific terms used that you did not understand?
Question 4: Were there any parts of the content that you would like different in order to make you understand the specific principle or element better?
Question 5: Do you think it would help you understand the content better if there were help available when you got stuck with an answer?
Question 6: Did it frustrate you much that there were no links in the tutorial to help you find specific principles or elements quicker instead of going back and forth all the time looking for something specific?

Addendum 4 Responses to the interview

Interview Participant 9
Question 1 "Teen die einde het ek afgerammel en het ek nie tyd gehad om terug te gaan na die wat ek nie verstaan het nie. *In the end I did rush and did not have time to go back to the ones I did not understand.*
Question 2 "Ja, party het meer prentjies gehad as ander, en party se prentjies was groter as ander s'n. Ek kon nie altyd uitmaak wat die elemente op die klein prentjies was nie. Dit het my deurmekaar gemaak. Party slides het meer geskryf op gehad as ander." *Yes, some had more pictures than others, and some pictures were bigger than others. I could not always identify the elements on the small pictures. That was confusing. Some slides had more text on than others.*
Question 3 "Ek dink ek verstaan balans want daar was baie slides daaroor. Maar toe ek die vrae in die oefening moes doen was ek nie seker of my antwoorde reg was nie." *I thought I understood balance because there were many slides covering it. But when I had to answer the questions, I wasn't sure I had the correct answers.*
Question 4 "Daar kan meer prentjies wees en hulle moenie te klein wees nie." *I would like more pictures and they should not be too small.*
Question 5 "Ja, ek din dit sou gehelp het. Dit kan ook tyd spaar." *Yes, I think it would. It could save time also*
Question *6* "Nee, ek het nie toe so daaraan gedink nie." *No. I didn't think of that at the time.*
Interview Participant 14
Question 1 "Nee, ek het ewe veel tyd gevat vir al die vrae." *No, I spent equal time one each question."*
Question 2 "Ek dink meer aandag moet geskenk word aan die 'design elements'". *I think more attention should be given to the design elements.*
Question 3 "Nee, ek het alles verstaan." *No, I understood everything.*
Question 4 "Nee, ek kan nie so sê nie." *No, I can not say so.*

Addendum 4 (cont)

Question 5 **"Ja, dit sou baie gehelp het. Ek dink ook dit so goed gewees om dadelik te weet of'n mens se antwoord reg is."** *Yes, it would help a lot. I also think it would be nice to know if your answer is correct straight away.*
Question 6 **"Dit was frustrerend, maar dit het ook partykeer gehelp om iets te sien wat jy nie juis soek nie, maar vir 'n ander vraag gehelp het."** *Yes, it was frustrating, but sometimes something you did not look for at the moment helped with answering another question.*
Interview **Participant 21**
Question 1 "Not really – no. But I do think it should have been scheduled for a separate session in the lab. We shouldn't have tried to do it all in one session".
Question 2 "It would be useful if there were explanations of some examples. To guide us in the technique of answering these type of questions.
Question 3 "No, everything was understandable."
Question 4 "No."
Question 5 "Yes, it would be reassuring. Sometimes you just didn't know if you are on the right track or not. You know, everything is so open-ended."
Question 6 "Yes, it could save a lot of time."

Addendum 5 The exercise

Design Problem Solving

Question 1: Name the way in which Unity is achieved here. Describe the elements used to achieve it.

Design Problem Solving

Question 2: Name the type of Balance achieved in this design. Describe the elements used to achieve this type of Balance

Addendum 5 (cont)

Design Problem Solving

Question 3: Critically discuss the way in which Proportion and Tonal Value acts to achieve Balance in this design.

Design Problem Solving

Question 4: Describe how Unity is achieved in this design.

Addendum 5 (cont)

Design Problem Solving

Question 5: Discuss the way in which emphasis on Unity is achieved in all three designs.

Design Problem Solving

Question 6: Discuss all the elements applied to achieve Unity in this design.

Addendum 5 (cont)

Design Problem Solving

Question 7: Discuss the elements used to achieve contrast in this design.

Design Problem Solving

Question 11: Describe how line is used to guide the viewer's eye through this design.

Addendum 5 (cont)

Design Problem Solving

Question 12: Discuss how the elements of Texture and Proportion bring interest to this design

Design Problem Solving

Question 13: Name and discuss the element used to achieve rhythm in this design.

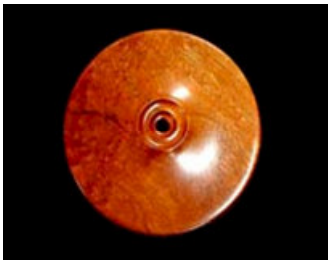
Addendum 5 (cont)

Design Problem Solving

Question 14: Discuss the type of Texture in this image.

Design Problem Solving

Question 15: Discuss the type of Balance in this three dimensional design of a wooden bowl.



Addendum 6 The exercise –analysis of responses

Participant 9 - Exercise		
Constructs	**Response**	**Comments/Interpretation**
Principle **Unity** **Question1** "Name the way in which unity is achieved here. Describe the elements used to achieve it".	"Unity is achieved in a way that the pictures in it are the same – both CD and both have pictures of people – repetition and continuation".	Principle understood: pictures are the "same" Technique used: repetition – not "continuation" Elements used: "pictures".
Question 4 Describe how unity is achieved in this design.	"Because the cosmetic bottles or tubes – with small triangles (repeatedly). Thus proximity and similarity unify a design. Repetition and continuation are the elements.	Technique: "how"? "Repetition and continuation" Principle understood? "Proximity and similarity" correct Elements – incorrectly identifies "repetition and continuation" – are in fact techniques – not elements.
Question 5 Discuss the way in which emphasis on unity is achieved in all three designs.	"Unity is achieved in a way that they are all ties, they are all striped".	Technique: Not discussed Principle understood: unclear Elements: "stripes" – correct.
Question 6: Discuss all the elements applied to achieve unity in this design.	"Repetition and continuation e.g. elephants and flowers. Unity with variety".	Technique: "repetition" correct "continuation" incorrect Principle not understood: "unity with variety" – this design is "emphasis on unity" Elements: refers to "elephants and flowers" – meaning, "shape?"
Question 8 "Name the dominant unifying element used in this design".	"Direction – colour – angle".	Element identified – colour "Direction" and "angle" not relevant to creating unity here. Not sure if she guessed.
Balance **Question 2** "Name the type of balance achieved in this design. Describe the elements used to achieve this type of balance".	"Symmetrical balance – shapes are repeated in the same positions on either side of a central vertical axis".	Principle not understood: "symmetrical balance" incorrect "similar objects … Technique used: Elements used: does not describe which elements.
Question 3 "Critically discuss the way in which proportion and tonal value acts to achieve balance in this design"	"Small words against the big word shows how relative size is"	Technique: Understand technique used: dissimilarity of "big" against "small" indicates understanding of proportion. Principle not understood: Does not refer to "balance" at all. Does not clarify meaning and application of "tonal value" Does not say what the writing is balanced with.

Addendum 6 (cont)

Participant 9 – Exercise		
Construct	**Response**	**Comments/Interpretation**
Question 15 "Discuss the type of balance in this three dimensional design of a wooden bowl"	"Shapes are repeated in the same positions on either side of a central vertical axis:	Principle not understood: does not identify it at all, i.e. "symmetrical balance", but repeats correct definition according to tutorial. Not sure if understands. No reference to specifics on the designs, e.g. circle/radiation.
Technique **Contrast** **Question 7** "Discuss the elements used to achieve contrast in this design".	"Repetition – continuation-illusion of motion".	Principle understood: "contrast" not understood Elements mentioned not relevant to the design.
Element **Texture & Proportion to achieve Contrast** **Question 12** "Discuss how the elements of texture and proportion bring interest to this design".	"Small human figure against the huge sunflower shows how relative the concept of size is. The dark areas represent smoothness and dark represents roughness".	Elements "proportion" correctly identified as "small" against "huge" as relativity of size in the design. "Texture" is not related to the design specifically. Participant gives definitions according to tutorial but does not identify "texture" on the design for what it is, i.e. dark spots in the middle of the flower in interesting contrast with lines in the petals.
Texture **Question 14** "Discuss the type of texture in this image".	"Tactile texture. It can be felt".	Principle understood: Correctly identifies "tactile texture" Not sure if understands why – does not refer to anything specific in the design - .can be felt" is repetition of definition in tutorial.
Illusion of movement **Question 9** "Discuss the way in which the illusion of movement is created in this design".	"The objects in the slide looks like they are moving and are repeated.	Technique: "repeated" correct Principle understood – not clearly explained.
Line **Question 11** "Describe how line is used to guide the viewer's eye through this design".	"The line represents the ends of the objects and their shapes".	Defines "line" correctly according to tutorial but does not understand its function.
Rhythm **Question 14** "Name and discuss the element used to achieve rhythm in this design".	"There seemed to some movement and repetition – repetition".	Technique: "Repetition" Principle understood: not clear if understands – does not discuss how repetition is applied to achieve movement.

Addendum 6 (cont)

Construct	Response	Comments/Interpretation
Technique **Repetition** **Question 10** **"Discuss the role repetition plays in this design".**	"Repetition play role in achieving unity and balance".	Principles achieved: unity and balance correct – does not discuss why – not sure if P9 understands how and why it is done.
Participant 14 - Exercise		
Construct	**Response**	**Comments/Interpretation**
Principle **Unity** **Question1** "Name the way in which unity is achieved here. Describe the elements used to achieve it".	"The circular shape Repetition Continuation".	Technique: "repetition" correct; "continuation" incorrect Principle understood: yes Element identified: "shape" correct.
Question 4 Describe how unity is achieved in this design.	"Repetition and continuation. Proximity and similarity unify a design Proximity – putting elements close together".	Not sure if understands – does not refer to specifics in the design – quotes definition in tutorial correctly.
Question 5 Discuss the way in which emphasis on unity is achieved in all three designs.	"Repetition. Continuation. Contain ordered quality of unity and the lively quality of variety".	Not sure if understands – does not refer to specifics in the design – wrongly identified – quotes wrong principle (should be emphasis on variety).
Question 6: Discuss all the elements applied to achieve unity in this design.	"Repetition. Some things repeat in various parts of design to relate to each other. (Proximity, shape, continuation)	Does not say which "things" repeat. Does not say which shapes are in proximity. "Continuation" incorrect.
Technique **Repetition** **Question 10** "Discuss the role repetition plays in this design"	Not answered.	**Not understood.**
Question 8 "Name the dominant unifying element used in this design".	"Focal point to catch attention".	"Unifying element" not understood.
Balance **Question 2** "Name the type of balance achieved in this design. Describe the elements used to achieve this type of balance".	"Asymmetrical balance is achieved with dissimilar objects that have equal visual weight or eye attraction".	Technique: not identified Principle understood: type correctly identified "asymmetrical balance". Not sure if understands – does not refer to specifics in the design – quotes definition in tutorial correctly.
Question 3 "Critically discuss the way in which proportion and tonal value acts to achieve balance in this design".	"Proportion refers to relative size, size measured against other elements".	Technique: not identified Principle not understood: does not relate elements to "balance" Elements understood: not sure – quotes only partially correctly according to tutorial.
Question 15 "Discuss the type of balance in this three dimensional design of a wooden bowl**".**	Not answered.	

Addendum 6 (cont)

Participant 14 - Exercise		
Construct	**Response**	**Comments/Interpretation**
Technique **Contrast** **Question 7** "Discuss the elements used to achieve contrast in this design"	"Size, overlapping, perspective"	None correct
Illusion of movement **Question 9** "Discuss the way in which the illusion of movement is created in this design".	"Figure repeated. Fuzzy outlines. Multiple images".	Correctly quoted from tutorial. Does not refer to anything specific in the design – not sure if understood.
Element **Line** **Question 11** "Describe how line is used to guide the viewer's eye through this design".	"Lines of keyboard takes they eye to the computer. A line is created by movement".	Understands what happens visually in this design _ line guiding eye's "movement" from keyboard to computer. "A line is created by movement" not relevant to the question.
Texture & Proportion **Question 12** "Discuss how the elements of texture and proportion bring interest to this design".	"Unrealistic proportions of the small human figure against the huge flower size. It creates surface quality".	"Proportion" correctly related to "small human figure" and "huge flower". "Flower" shows "surface quality" but NOT that of figure. Not sure participants understands the effect of the texture – i.e. tactile quality.
Texture **Question 14** "Discuss the type of texture in this image".	"Visual texture refers to the surface quality of objects".	Type of texture incorrectly identified. Quotes wrong definition from tutorial. Does NOT understand.
Rhythm **Question 14** "Name and discuss the element used to achieve rhythm in this design".	"Movement of the viewers eye. Design principle is based on repetition".	Correctly quoted from tutorial. Does not refer to anything specific in the design – not sure if understood.

Participant 21 - Exercise		
Construct	**Response**	**Comments/Interpretation**
Principle **Unity** **Question1** "Name the way in which unity is achieved here. Describe the elements used to achieve it".	"The objects look like they belong together. There is repetition of the shape of the c.d. Having the same texture and shape in the same direction".	Principle understood: "belong together", "repetition", "same" Technique used: repetition Elements used: Shape.
Question 4 Describe how unity is achieved in this design.	"By repetition and continuation. The proximity and similarity unifying the design. Unity is achieved by shape, colour, direction and the angle of the containers".	Technique: "how"? "Repetition and continuation" Principle understood? Yes – "proximity and similarity" Elements identified? Shape, colour, angle.

Addendum 6 (cont)

Construct	Response	Comments/Interpretation
Question 5 Discuss the way in which emphasis on unity is achieved in all three designs.	"The design contains both the ordered quality of unity and the lively quality of variety. The design encompasses the wide variety of extremely different visual images".	Technique: Not discussed Principle understood: No P21 refers to unity with variety and not to emphasis on unity Elements: None identified.
Question 6 Discuss all the elements applied to achieve unity in this design.	"You can see the objects belong together, through visual connection. There is repetition, repeating pictures to relate to each other".	Technique: repetition, Principle understood: yes "visual connection" Elements: none given.
Technique **Repetition** **Question 10** "Discuss the role repetition plays in this design".	"Something repeats in various parts of the design to relate the parts to each other – same shape and texture are repeated".	Technique understood: repetition Principle achieved: not named as "unity" – but "relate parts" implies it Elements identified: "shape and texture" correct.
Question 8 "Name the dominant unifying element used in this design".	"Emphasis on unity".	Element not identified – colour Equated "emphasis on …" with "dominant" Question not understood.
Principle **Balance** **Question 2** "Name the type of balance achieved in this design. Describe the elements used to achieve this type of balance".	"This design has asymmetrical balance, having dissimilar objects that have equal visual weight or equal eye attraction".	Principle understood: asymmetrical balance "dissimilar objects … equal visual weight" Technique used: correctly "dissimilarity", "visual weight" Elements used: does not describe which elements.
Question 3 "Critically discuss the way in which proportion and tonal value acts to achieve balance in this design".	"Tonal value helps with contrast without disturbing unity. The writing takes up most of the space overwhelming the design. This balances the design as asymmetrical balance".	Technique: Understand technique used "space overwhelming by…" Principle understood: Correctly identifies "asymmetrical balance" indicates understanding of "proportion". Does not clarify meaning and application of "tonal value" Does not say with what the writing is balanced.
Construct	**Response**	**Comments/Interpretation**
Question 15 "Discuss the type of balance in this three dimensional design of a wooden bowl"	No answered	

Addendum 6 (cont)

Technique **Contrast** **Question 7** "Discuss the elements used to achieve contrast in this design".	"Symmetrical balance. Like shapes are repeated in same positions on either side of central vertical axis. Distributing visual weight equally".	Principle understood: identified correctly as "symmetrical balance", repeats correct definition according to tutorial. Not sure if understands. No reference to specifics on the designs, e.g. circle/radiation
Illusion of movement **Question 9** "Discuss the way in which the illusion of movement is created in this design".	"The horizontal line across the vertical lines creates visual tension, preventing visual boredom".	
Element **Line** **Question 11** "Describe how line is used to guide the viewer's eye through this design".	"The figure has been repeated with a fuzzy outline of multiple images".	Technique + elements: "repeated" "fuzzy outline" "multiple images" Principle understood.
Texture & Proportion **Question 12** "Discuss how the elements of texture and proportion bring interest to this design".	Not answered.	Function of "line" not understood.
Texture **Question 14** "Discuss the type of texture in this image".	"Texture: it looks as if you can actually touch it. The little man that is small emphasises the sizes and proportions if objects compared to each other".	Elements "texture" and "proportion" not recognised/identified on the design for what it is, i.e. dark spots in the middle of the flower in interesting contrast with lines in the petals.
Rhythm **Question 14** "Name and discuss the element used to achieve rhythm in this design".	"Visual texture, created by varying the pattern of light and dark areas on the object. This gives the impression of depth to the image	Principle not understood. "Visual texture" not correct. Participant repeats definition on tutorial of incorrect principle.
	"Repetition is the element used to achieve rhythm. Repetition is an element of visual unity. Giving the design movement of the viewer's eye"	Technique: "Repetition" Principle understood: partly – "repetition" – does not sufficiently explain that repetition must form a pattern in order to create rhythm.

Addendum 7 The exercise – researcher's analysis of designs

1. Question 2

"Name the type of balance achieved in this design. Describe the elements used to achieve this type of balance".

1.1 The criterion

Participants had to do two things in order to answer the question correctly. First, they participants had to name the type of balance correctly, i.e. asymmetrical balance. Second, they had to describe all the design elements used to achieve it.

The tutorial explains that symmetrical balance is achieved when like shapes are repeated in the same positions on either side of the central vertical and/or horizontal axes. Asymmetrical balance is achieved when dissimilar objects on the format have equal visual weight or equal eye attraction.

Multiple possible combinations of design elements could be identified as contributing to the achievement of asymmetrical balance. However, participants had to correctly explain their understanding or conceptualizing of the visual and spatial effect the arrangement of the elements would have on the equal distribution of the elements around the central axes.

1.2 Analysis of the constructs in the question

The image in question 2 illustrates how dissimilar objects with equal visual weight are used has to achieve asymmetrical balance on the format. The designer used the elements of dissimilar size and tonal value to achieve asymmetrical balance. The two organic shapes appear to be the exactly same, but the difference in size or scale and tonal value distribute the visual weight around the vertical and horizontal axes of the format. The shape on the left of the vertical axis is much bigger, but much lighter in tonal value than the shape on the right. The designer furthers used the large white text on

Addendum 7(cont)

top of the big shape to even further lighten the tonal value, reducing the visual weight equal to that of the small, dark shape on the right. Objects around the horizontal axis are also placed in such a way that asymmetrical balance is achieved. The big darker shape in the top left quarter is visually balanced with the lighter empty space on the right top quarter. The whole top half is much darker in tonal value than the bottom half, but balance is achieved by the equal visual weight of the tonal value of the dark top with the light bottom.

2. Question 9

"Discuss the way in which the illusion of movement is created in this design"

2.1 The criterion

Participants had to identify the techniques used to achieve the design principle of illusion of motion in order to answer the question correctly. They were not required to identify the design elements used in the design, but those participants who did refer to e.g. line, shape, size, colour, texture correctly were considered as having a good understanding of the structure of the design in question 9 as it is not possible to talk about using techniques without referring to what elements they have been applied to.

2.2 Analysis of the constructs of the question

In the tutorial, 6 possible techniques to create the illusion of movement were identified in slide 39 and 40 illustrated in slides 40, 41 and 42. They were overlapping, repetition of figures, fuzzy outlines, anticipated movement, multiple images and optical movement.

In question 9 illustrated above, five techniques were used to achieve the design principle illusion of motion, i.e. repetition and overlapping of the square shapes, very fuzzy outlines and blurred images

Addendum 7 (cont)

and optical movement achieved by the strong diagonal lines crossing the format from top left to the middle, to achieve the illusion of movement.

3. Question 12

"Discuss how the elements of "texture" and "proportion" bring interest to this design"

3.1 The criterion

Question 12 required students to identify the design elements proportion and texture. Participants had to identify the relevant slide on the tutorial and understand that the small human figure is compared to the gigantic sunflower, is unrealistic.

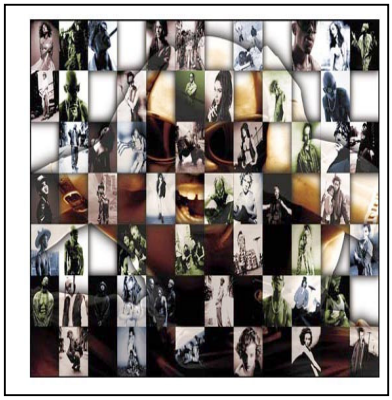
The researcher looked for elements in the responses referring to the relevant explanatory text on the tutorial. Slides 33 and 34 explain the difference between tactile texture and visual texture. "*We experience texture when we touch objects and feel their roughness, smoothness or patterns - called "Tactile Texture … Visual Texture is created by varying the pattern of light and dark areas on an object …".* Proportion is described on slide 22 in the following way: "*Proportion refers to relative size, size measured against other elements or against some mental norm or standard.*"**3.2 Analysis of the constructs of the question**

The image in question 12 was taken from the tutorial; slide 22, which explains the design principle of scale and proportion. Proportion is explained on slide 22 as a synonym for the term "scale". The slide

Addendum 7 (cont)

also explains that one can only talk about proportion if one compares two different sizes with each other. On the same slide the exact same image illustrating proportion than the one used in question 12, with an explanation of how proportion works on the image*: "(b) The unrealistic proportions of the small human figure against the huge sunflower, shows how relative the concept of size is"* (slide 22). Analysing the image further, it seems that, because of the large scale of the sunflower compared to the small size of the human figure, the texture on the pollen and petals appears very tactile causing the sunflower to become the "mountain" the human climbs, which is one way of seeing the interest caused by texture and scale.

Addendum 8 The test – questions regarding visual analysis

Questions 5 **Identify all the design principles achieved in each of the designs below. Explain which design elements have been used to achieve this and how it was achieved.**		
5.1 	**5.2** 	**5.3** 

Addendum 9 The test – analysis of the designs in questions pertaining to visual analysis

Question 5. 1

Analysis of the constructs in the design

The design principles achieved in this design, were numerous. First, illusion of motion was achieved through the use of diagonal lines and the circular direction at which the small figures in the rectangles are placed around the big moving figure in the centre, causing the viewer's eye to move around the format. Second, unity with variation is achieved by repeating the shape, size and tonal value of the rectangles. Subtle variety is achieved by contrasting the dominating unity of the geometric rectangles with organic human figures. The shaded lines delineating the rectangles as well as the figures, creating depth and visual texture, further achieve unity. Variety is further achieved by contrasting the small figures in the rectangles with the large figure in the centre. Emphasis is created through confronting the viewer with the large figure in the centre, with the open mouth as focal point. Illusion of space is achieved through the visual texture created by varying the pattern of light and dark areas on the format. Areas of light and dark give the impression of depth to the rectangles and large figure in the centre. The transparency of the large figure in turn contributes to texture, illusion of depth and space. The principle of asymmetrical balance was achieved by the large top part in the light tonal value of above the horizontal axis balancing the smaller dark part at the bottom of the horizontal axis, using the technique of equal distribution of visual weight with dissimilar objects.

The minimum constructs a participant had to refer to in the response, were:
Design principles: scale and proportion, unity, emphasis,
Design elements: line; shape; tonal value; size and texture
Techniques: illusion of motion, diagonal lines, circular direction, contrast, variety, transparency, and repetition.

Question 5.2

Analysis of the constructs in the design

The design chosen for question 5.2 is a 2-D graphic design of an advertisement on a poster. It was chosen to balance the level of difficulty that was considerably higher in question 5.1 and 5.3, because the researcher considered the design principles and design elements easier to read than in the other two questions. Images are much more recognisable and less cluttered on the format than in the design below.

Addendum 9 (cont)

Design principles achieved in this design, were numerous. First, unity with variation was achieved by repeating circular shapes of the grapes, bananas, and bowl and second, the curved feminine lines of stem of bowl, woman's neck, flowers. Contrasting big shapes, e.g. the bowl and the woman's face with the small shapes of the grapes, flowers, bananas, achieved the principle of scale and proportion. Emphasis was achieved by the multi-layering of the red area in the wine glass and fruit over the

woman's face, which is in turn pulled down by the red area at the right towards the bottom part of the design where the viewer's eye rests on the text. Emphasis is strengthened by the contrast between black band at the bottom and curved line of grapes leading the eye to bottom part of the format. Illusion of space is created by the transparency of glass bowl contributes to illusion of depth and space as well as by the dark tone in the background that creates depth. At the same time contrasting sizes of the small grapes against the large wine glass and face, achieves the principle of scale and proportion. Asymmetrical balance is created by the equal distribution of visual weight of dissimilar objects on both sides vertical axis. This can be seen in the small dark grapes on left equal in visual weight than light large face on right.

The minimum constructs a participant had to refer to in the response, were:
Design principles: emphasis, unity with variation; scale and proportion, balance, illusion of space,
Design elements: size, shape, line, tonal value, colour, texture
Techniques applied: contrast, repetition, transparency, layering

Question 5.3

Analysis of the constructs of the question

Unity with variation was achieved by applying the technique of sameness, i.e. repeating shapes that look as if they belong together, e.g. the curved lines of handle, spout and decoration of kettle. It was further created by repetition of the circular shapes of the lid, and the spout. Asymmetrical balance was achieved by the equal visual weight of the dissimilar long solid spout on the left of the vertical axis and the short sharp curved open shape of the handle on the left of the vertical axis. Tactile texture is created by the thick application of the blue and yellow enamel on the red background of the teapot. Emphasis is on the small light handle of the geometric lid, contrasted by the large size of the curved handle as well as by the dark background in the picture.

The minimum constructs a participant had to refer to in the response, were:
Design principles: illusion of motion; unity with variation; emphasis; balance; scale and proportion
Design elements: line; shape; tonal value; size and texture
Techniques: contrast, transparency

Addendum 10 The test – scoring criterion for questions regarding visual analysis

Level of knowledge, understanding and skill	Explanation	Scoring
Identify minimum design principles only	Indicate very poor retention, but no understanding and analytical skill	- 40%
Identify some design principles and elements only	Indicate poor retention and understanding and no analytical skill	40 – 50%
Identify minimum design principles and design elements only	Indicate average retention but limited understanding	50 – 69%
Identify minimum design principles and design elements and explain techniques used to achieve the visual effect	Indicate above average retention, understanding and skill	70 – 79%
Identify more than the required minimum design principles and elements and explain interaction between constructs in operation well	Indicate good retention and good understanding of constructs and analytical skills	80% +

Addendum 11 The test – questions regarding drawings

Question 1 Illustrate the design principle of “unity” achieved by shape and pattern.
Question 2 Illustrate the design principle of “asymmetrical balance” achieved by size and tonal value”.
Question 3 Illustrate the design principle of “visual texture” achieved by line, tonal value and shape.

Addendum 12 The test - rating system for questions regarding drawings

Scale: Poor = 0 – 3, Average = 4 – 6, Good = 7 – 10

Participant	**Constructs**				**Average for learning after some time**
	Principles	Elements	Techniques	Visual interest	
Participant 9	5	4	3	3	4
Participant 14	5	5	5	3	4
Participant 21	7	5	5	3	5

Addendum 13 The project – scoring system for cognitive indicators

Construct	Coding	Cognitive indicator
Design principles	Unity, balance, scale, proportion, emphasis, rhythm, illusion of space.	Clarity of realisation of design principles.
Design elements	Line, shape, size, texture, illusion of movement, colour, tonal value.	Number of and interesting way in which design elements used.
Design techniques	Repetition, addition, omission, distortion, enlargement, diminution.	Visual interest created through variety and creativity of techniques used.

Weight

Very poor (0 – 29%)
Poor (30% - 49%)
Average (50% - 64%)
Good (65% - 75%)
Very good (76% - 100%)

Addendum 14 The examination – scoring system for cognitive indicators

Construct	Coding	Cognitive indicator
Design principles	Asymmetrical balance, unity in lamp shade and its stand	Clarity of realisation of design principles.
Design elements	Line, visual texture,	Number of and interesting way in which design elements used.
Design techniques	Contrast	Variety and creativity of techniques used to create visual interest.
Idea	Create soft, intimate light	Clarity of idea.

Weight

Very poor (0 – 29%)
Poor (30% - 49%)
Average (50% - 64%)
Good (65% - 75%)
Very good (76% - 100%)

Addendum 15 Adequacies for electronic learning support material according to Hannafin and Peck (1988)

Adequacy	Description
Instructional adequacy: Refers to the extent to which the intervention provides the necessary supports and features to accomplish the objectives at hand	• Goals and objectives clear • Navigational and instructional directions • Learner control • Relate to prior knowledge • Questions asked frequently • Give "help" • No vague and ambiguous • Important terms, concepts and information amplified effectively • Emphasis distributed • Opportunities for interaction • Personalized instruction
Programming adequacy Refers to the degree to which the intervention is executed	• Program free of conceptual and programming loops • Disk management requirements minimal • Intervention runs efficiently • Information displayed accurately • Components logically and systematically located
Curriculum adequacy Refers to the degree to which the intervention procedures, activities and formats are consistent with accepted standards	• Content relevant and consistent • Approach consistent • Learning support material consistent • Procedures consistent with expectations • Complete in time • Information relevant
Cosmetic adequacy Refers to the visual appeal the intervention has for the learner	• Screen space used effectively • Protocol consistent and effective • Information presented free of crowding and cramming • Appropriate organisation of information • Presentation short