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:

- 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 and technology, learning and instruction and teacher education and 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.

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

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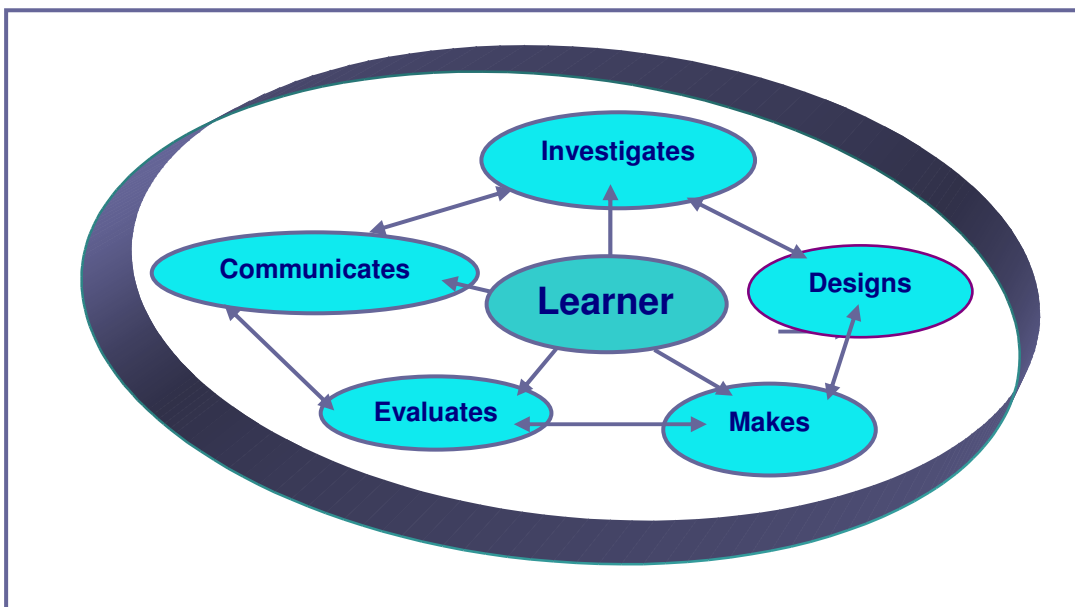
Figure 1.1   A model of the design process as prescribed by the *Revised National Curriculum Statement Grades R-9* (DoE, 2002)

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:

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[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.
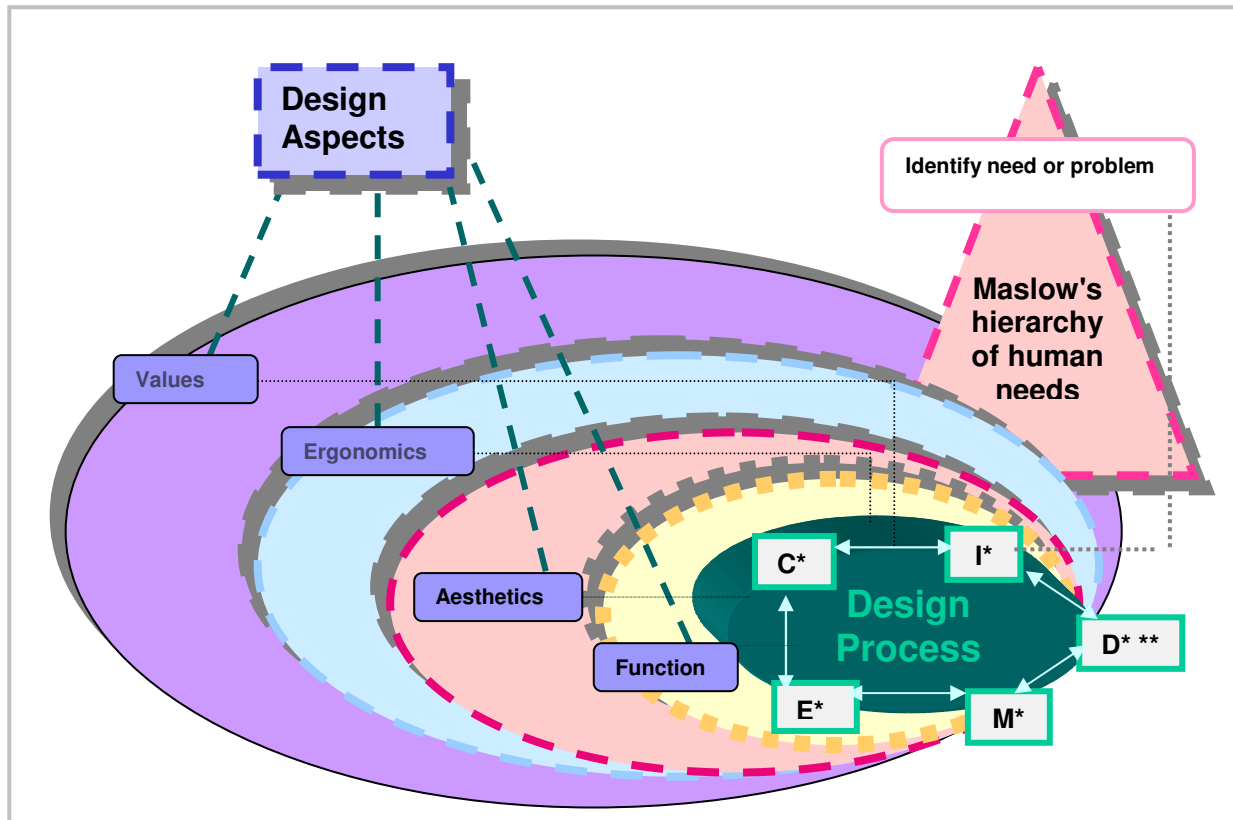
1.3.3   The structure of the module

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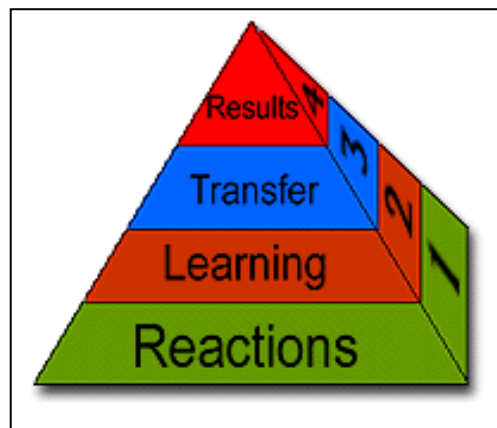
Figure 1.3   Kirkpatrick's model of the levels of learning (Winfrey, 2002)

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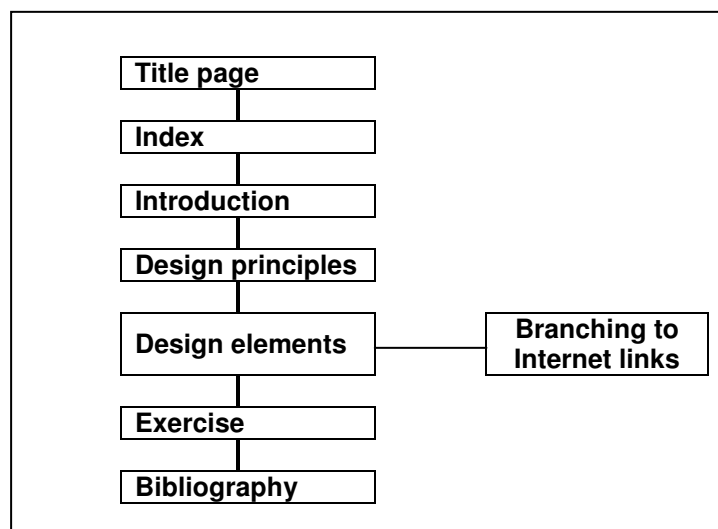
Figure 1.4   Structure and sequence of the tutorial *Design in Action*

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.
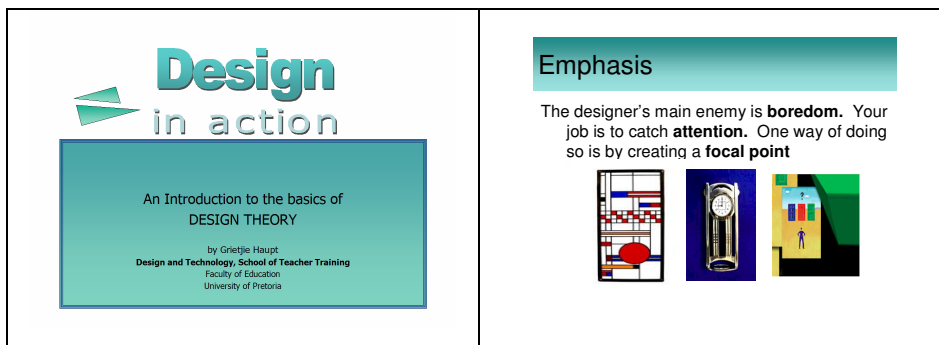
Figure 1.5 Screen shot of the style   **Figure 1.6 Screen shot of the style**
of presentation in the tutorial   **of presentation in the tutorial**

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).
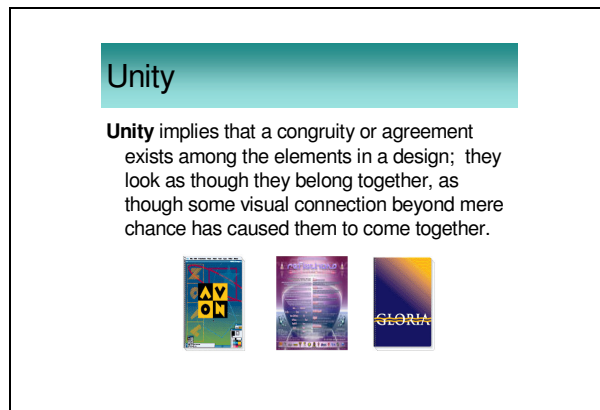

Figure 1.7 Example of the definition screens

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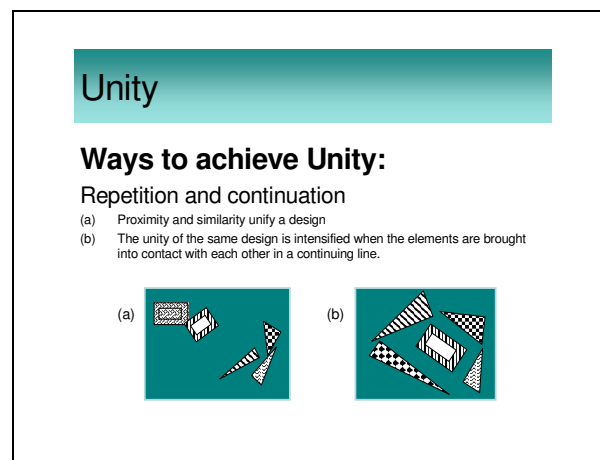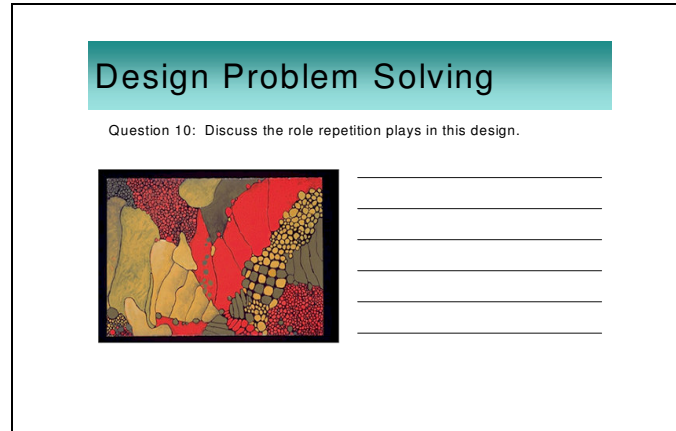

Figure 1.8 Example of an instructional screen

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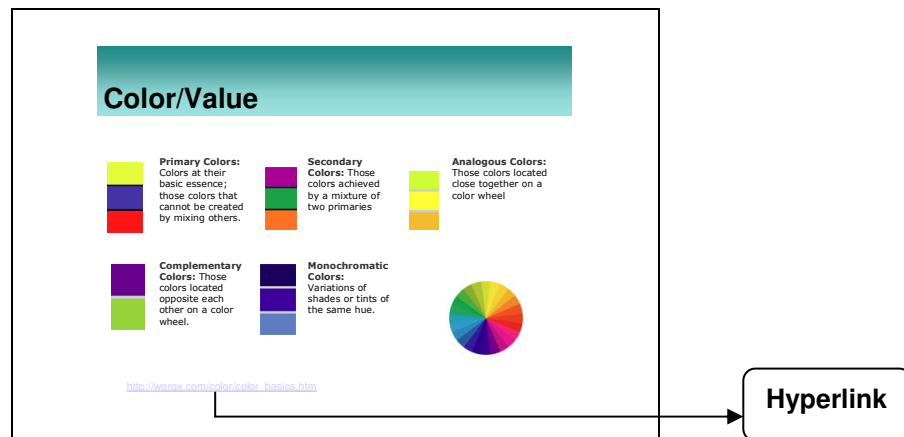
Figure 1.10 Example of a screen with a link to the Internet

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.