

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 interpretivist and development. The interpretivist 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 deduced 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.

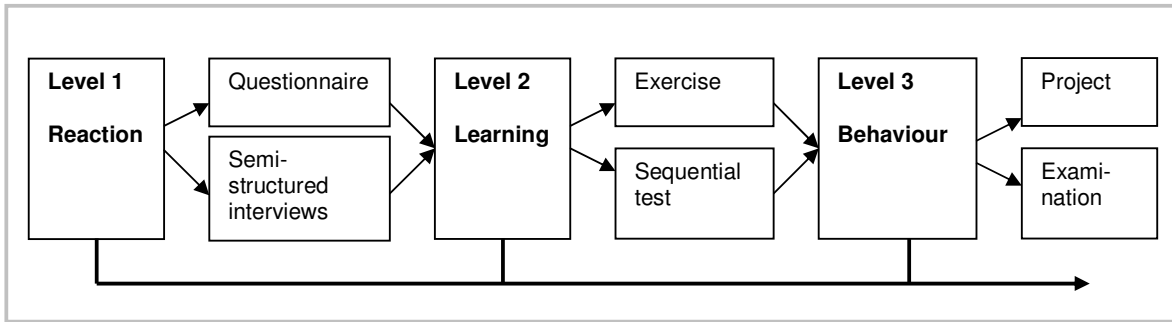


Figure 3.1 The research plan

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).

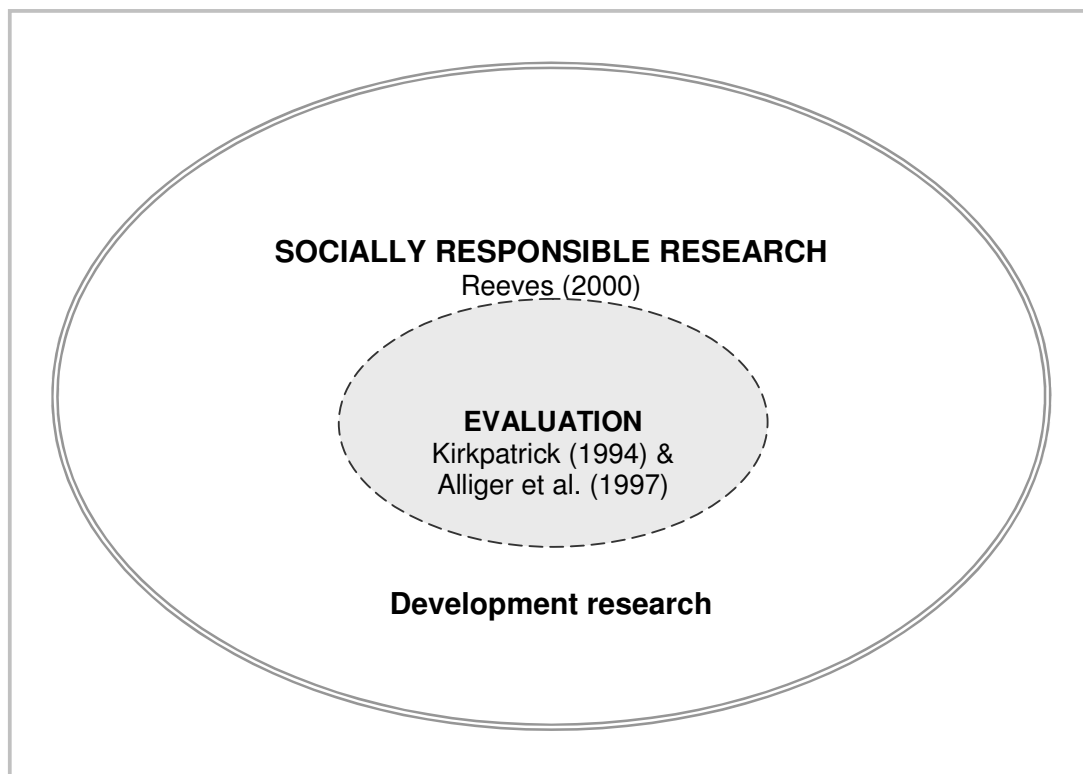


Figure 3.2 Theoretical framework of the research

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 “coach” 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 Utility judgments	Participants’ perceptions of the intervention – generally their satisfaction with the training 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 Learning after a period of time	The assessment of knowledge acquisition at the conclusion of the intervention The retention of knowledge at some point after the immediate conclusion of the intervention
Level 3 Behaviour:	Transfer of knowledge and skills Sustained performance	Demonstrated performance after a period of time 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 teachers⁵;
- 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 <i>et al.</i> , 1997)
2.	Design a form that will quantify reactions		✗	Designed a form allowing for qualitative responses for spontaneity and unbiased responses (Cohen <i>et al.</i> , 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 <i>et al.</i> , 1997) Encouraged detail and specificity (Cohen <i>et al.</i> , 2000)
3.	Encourage written comments and suggestions	✓		
4.	Get 100 percent immediate response	✓		All 22 participants responded immediately after completing the tutorial (Kirkpatrick, 1994) Encouraged honesty (Cohen <i>et al.</i> , 2000) Content analysis measured against recognised constructs to achieve objective interpretation of open-ended written responses (Cohen <i>et al.</i> , 2000) A criterion-related coding systems was developed for setting standard and unbiased analysis of responses (Cohen <i>et al.</i> , 2000) Documented and analysed (Cohen <i>et al.</i> , 2000)
5.	Get honest responses	✓		
6.	Develop acceptable standards	✓		
7.	Measure reactions against standards, and take appropriate action	✓		
8.	Communicate reactions as appropriate	✓		

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.		X	Because of time constraints and the structure of the module, it was not practical to use a control group. 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. All three participants engaged in the evaluation. Results were used to determine the course of the rest of the module as well as of the remainder of the data generating strategies.
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.	✓		
3.	Get a 100 percent response.	✓		
4.	Use the results of the evaluation to take appropriate action.	✓		

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 were 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).

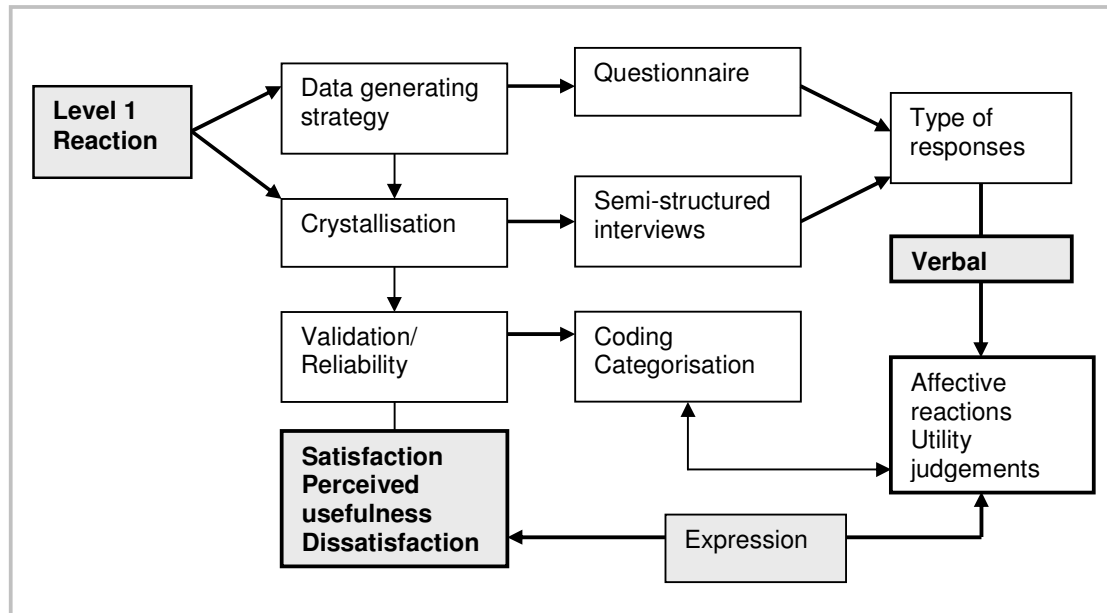


Figure 3.3 Data capturing for research question 1 (evaluating level 1 – reaction)

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.

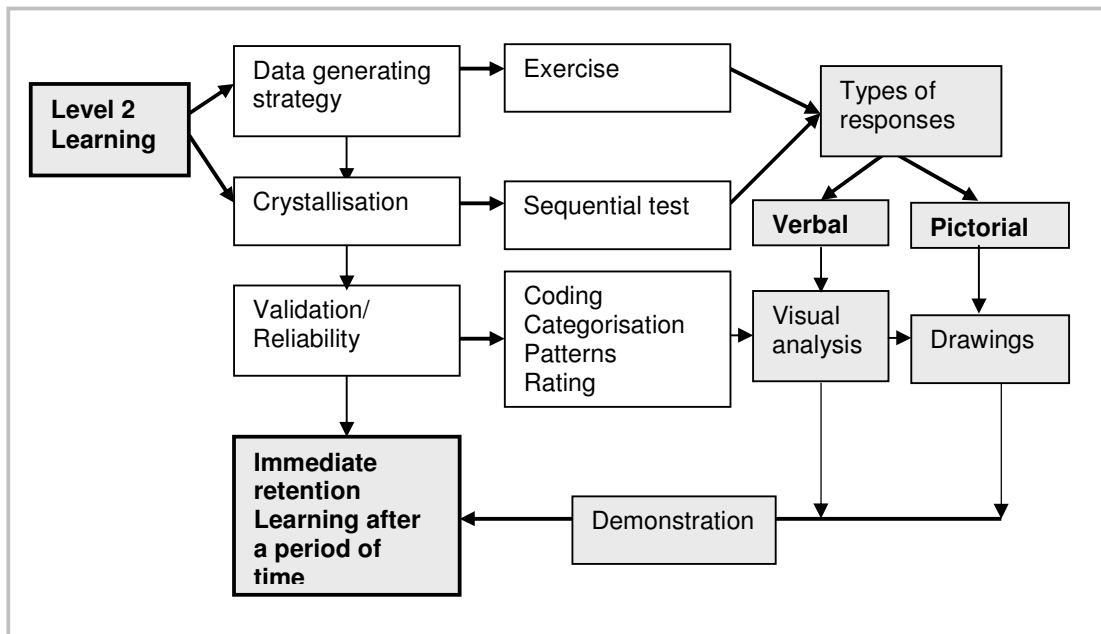


Figure 3.4 Data capturing for research question 2 (evaluating level 2 – learning)

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.

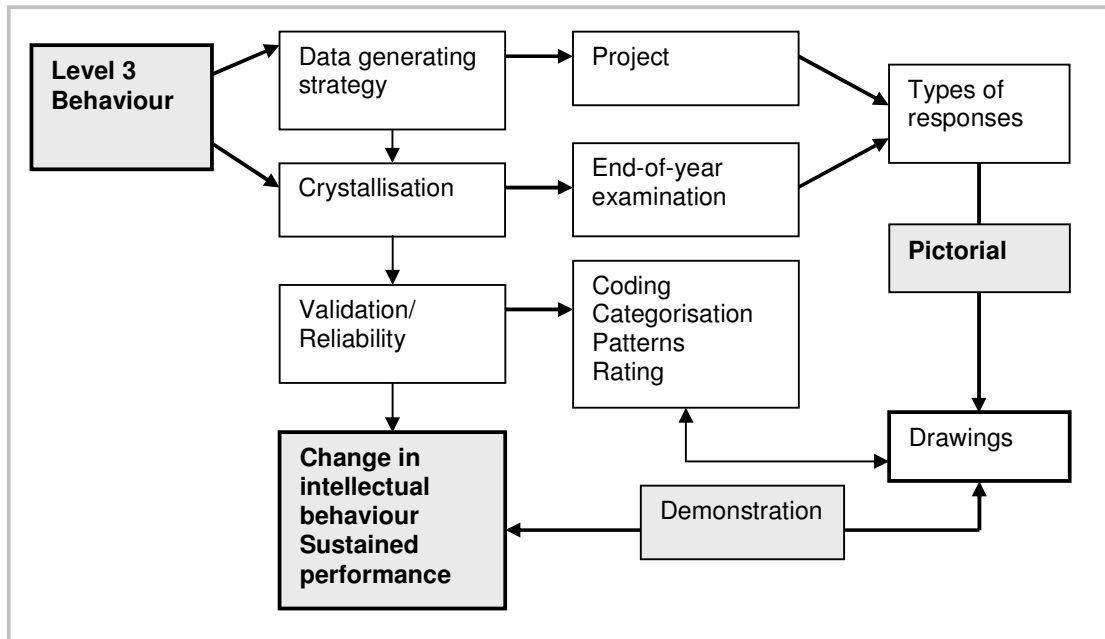


Figure 3.5 Data capturing for research question 3 (evaluating level 3 – behaviour)

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:

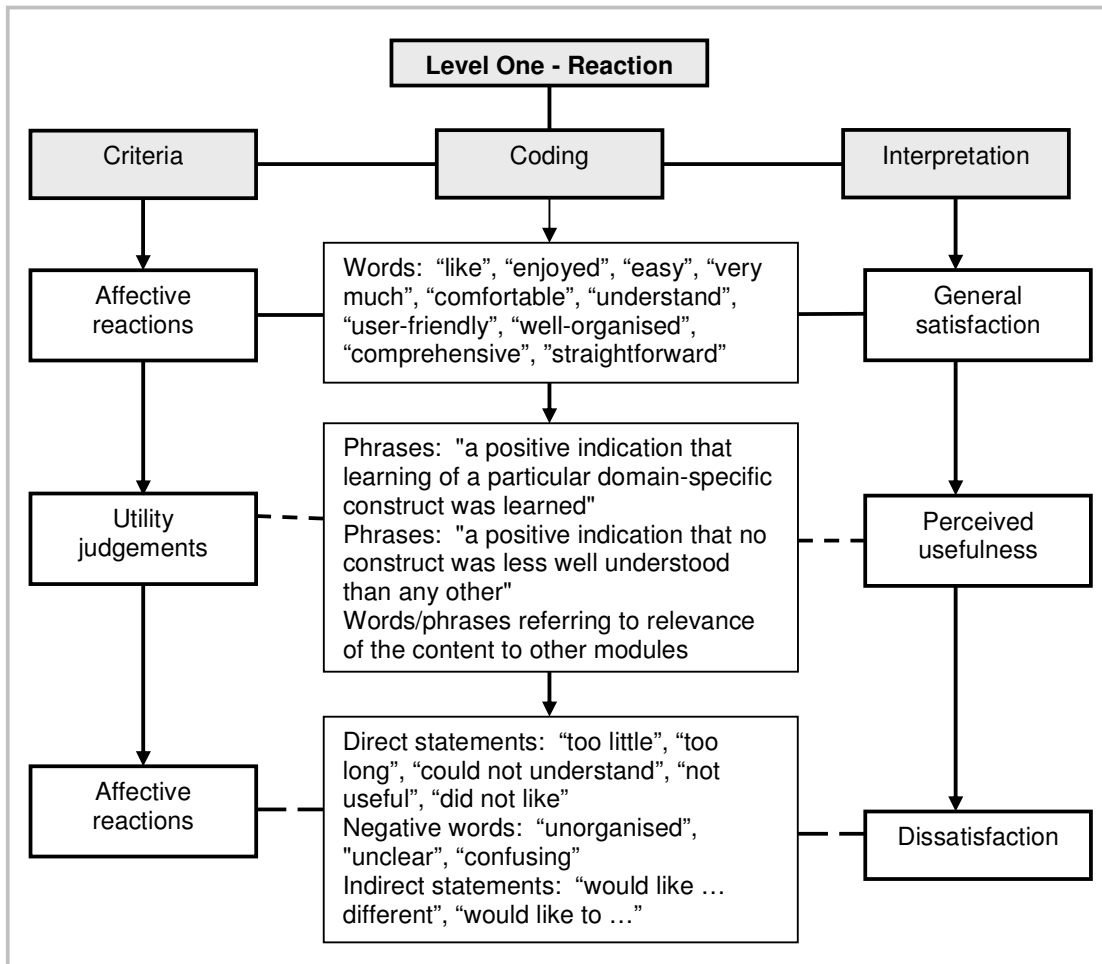


Figure 3.6 Analysing data for Research Question 1 (evaluating Level 1 – Reaction)

- 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

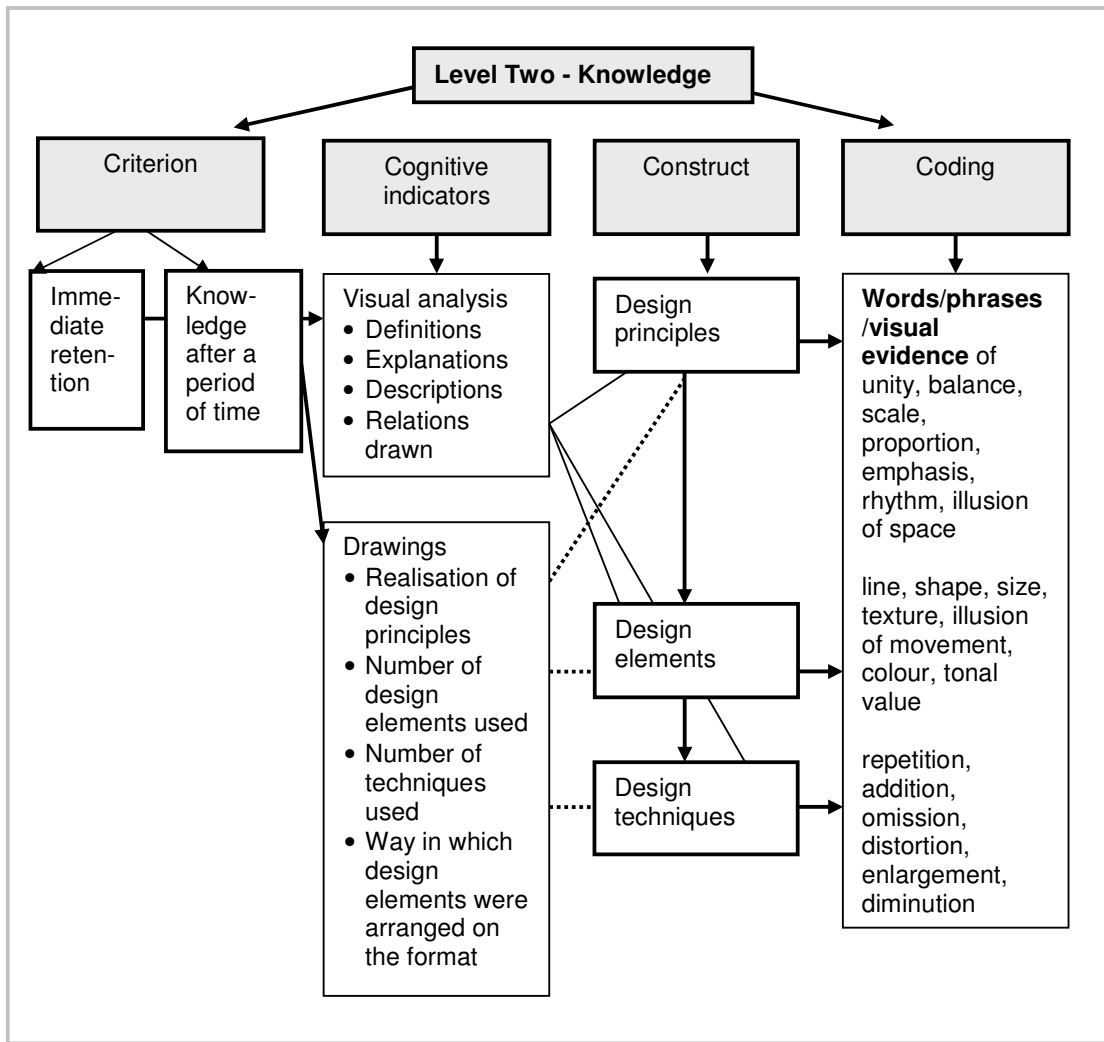


Figure 3.7 Analysing data for research question 2 (evaluating level 2 – knowledge)

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.

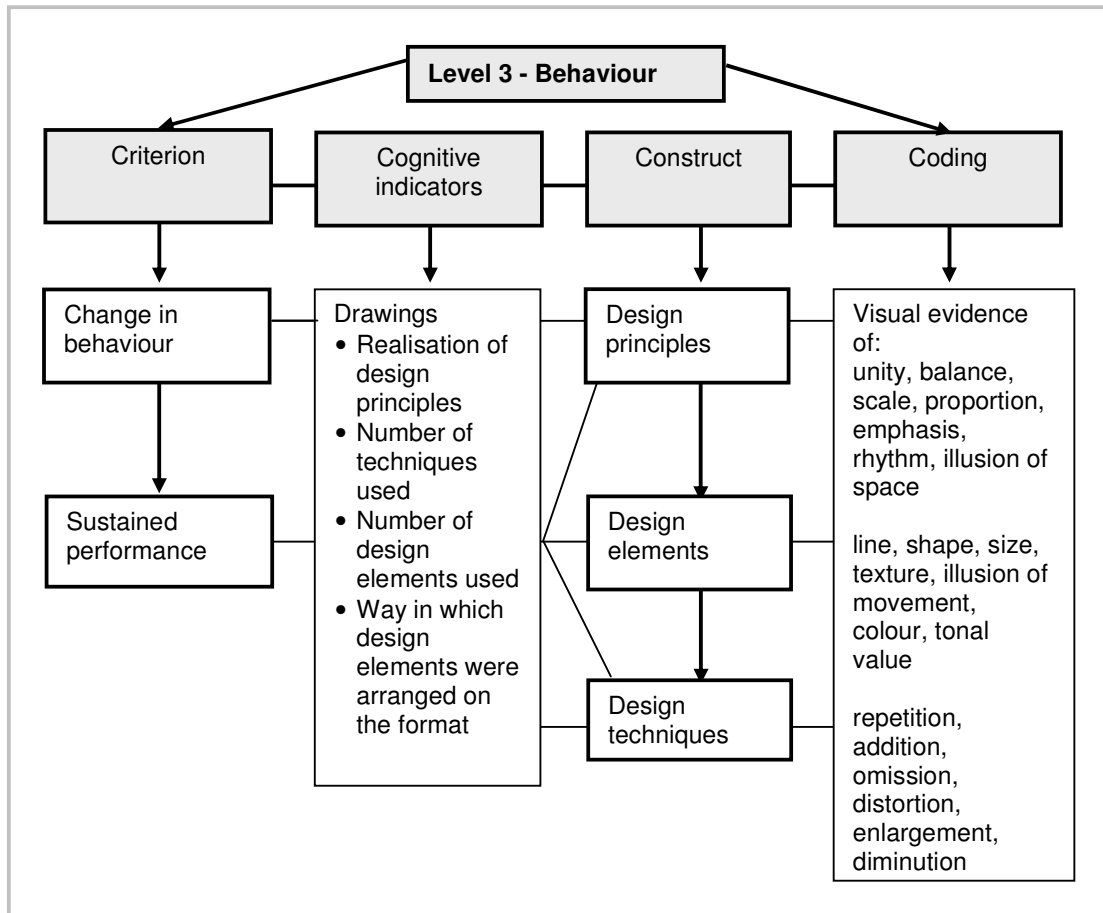


Figure 3.8 Analysing data for research question 3 (evaluating level 3– behaviour)

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 analyst 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 model 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.