Chapter 3
Research design and research methods

This study aims at formulating design principles in the form of conjectures and principles and at exploring the experiences of students who have worked within a learning environment based on these conjectures and principles. The learning environment uses computer technology as a cognitive tool in the form of an expert system shell in order to facilitate higher-order thinking skills in students. This chapter discusses the research design and the methods used to formulate these conjectures and principles and to explore the students' experiences. The chapter begins with an outline of the philosophical worldview that frames the study and then goes on to outline in detail how a design-based research approach was adopted during the study. The sampling methods applicable to both sets of samples used in the research are explained, followed by a detailed explication of the data collection and analysis techniques employed. The chapter concludes with a discussion of the trustworthiness of the findings and the ethical considerations applicable to the study.

3.1 Philosophical worldview applicable to this study

Creswell (2009, p. 6) uses the term "worldview" to describe the "general orientation about the world and the nature of the research that the researcher holds". He points out that this encompasses "what others have called" (ibid.) paradigms, epistemology, ontology and methodology. The philosophical worldview adopted in this study is closely allied to the social constructivist worldview. In a social constructivist worldview the objective of research "is to rely as much as possible on the participants' view of the situation being studied" (Creswell 2009, p. 9). The meaning inherent in a particular situation is commonly determined through "discussion or interaction with other persons" (ibid.). In this worldview the generation of meaning is invariably social and results from "interaction with a human community" (ibid.). Focus group interviews were principally used as a data collection method during this

study in order to explore "multiple viewpoints or responses" concerning a specific issue (De Vos *et al.* 2009, p. 300). The emphasis was to uncover a "socially constructed meaning of reality as understood by an individual or group" (Guo & Sheffield 2007, p. 675). Creswell (2009, p. 8) points out that a social constructivist worldview is often combined with interpretivism. Carcary (2009, p. 12) indicates that distinct from a more positivistic perspective, "physical-law-like generalisations are not the end product" of an interpretive approach. In contrast "understanding through detailed descriptions is sought by answering questions such as '*what*?', '*why*?' and '*how*?'". Qualitative research methods are emphasised within interpretivism "where words and pictures as opposed to numbers are used to describe situations" (ibid.).

3.2 Strategy of inquiry

Creswell (2009, p. 11) proposes that strategies of inquiry "provide specific direction for procedures in a research design" and he distinguishes three broad groupings in this regard: quantitative, qualitative and mixed method. This study adopted a qualitative strategy of enquiry using a grounded theory approach to data collection and analysis.

3.3 Design-based research

This study employs a research design that is based on many of the principles associated with educational design-based research (Discussed in detail in Chapter 2). Reeves, Mc Kenny and Herrington (2011, p. 56) state that educational design-based research is an effective method of "solving real problems in practice and to advancing theoretical understanding as well". This would allow the research to be more meaningful as it provides a direct association between research and practice (ibid.). Design-based research is considered particularly appropriate for the exploration of "technology-based initiatives" (Parker 2011, p. 1).

3.3.1 How this study employs educational design-based research

A review of the literature (Fisk & Ladd 2005; Stephen, Welman & Jordaan 2004; Thanosoulas 2001; McLaughlin 1999; Bothma, Botha & Le Roux 2004; Jaffer, Ng'ambi & Czerniewics 2007; Scott & Yeld 2008; Legotlo *et al.* 2002*;* Van der Berg & Louw 2006; Howie 2003; Ngidi & Qwabe 2006; Schlebush & Thobedi 2004) has established that students typically enter higher learning institutions academically under-prepared and are unable to employ higher-order thinking skills effectively when engaging with subject matter. A prototype of a learning environment that uses technology as a cognitive tool in the form of an expert system shell was designed, using the researcher's creativity as well as by referencing the appropriate literature in this regard. This learning environment aimed at facilitating higher-order thinking skills in Foundation English Communications Skills students at TUT. It was considered to be a part of a "proposed solution" (Herrington *et al.* 2009, p. 129) to the academic under-preparedness of these students. A design team comprising experienced English Communications lecturers as well as instructional designers was presented with this provisional design of a learning environment in order to facilitate a process of improvement and refinement of the environment. Ten contact sessions were held with this design team with the researcher making "adjustments and improvements" (ibid.) after each session. The sessions came to an end when the proposed learning environment was generally considered to be ready for implementation in an authentic educational setting.

3.4 Sampling methods

A purposive sampling method was used in the selection of members of the design team and simple random sampling was used to select a sample from the student population.

3.4.1 Purposive sampling

When choosing purposive sampling the researcher samples with a purpose in mind (Trochim 2001, p. 56). White (2005, p. 120) indicates that purposive sampling is undertaken on the "basis of the researcher's knowledge of the population" and as a result of this knowledge a considered decision is made concerning which individuals to select in order to "provide the best information to address the purpose of the research" (ibid.). Purposive sampling involves the researcher making a critical assessment concerning the characteristics and attributes of the population and then selecting the sample accordingly (De Vos *et al.* 2009, p. 329). Members of the design team, that was assembled in order to design a learning environment that uses technology as a cognitive tool to develop higher-order thinking, were selected using a purposive sampling method. This design team consisted of six individuals with two distinct professional backgrounds. Two of the members were instructional designers from the Teaching and Learning with Technology (TLT) department at the Tshwane University of Technology (TUT); the remaining four individuals were all English Communication Skills lecturers at TUT. This team provided the researcher with a suitable blend of experience and skill in the field of educational technology as well in the teaching of English Communication Skills, which constituted the subject domain of the learning environment. The ten design sessions were all conducted at the Pretoria West campus of the Tshwane University of Technology.

3.4.2 Simple random sampling

To explore how the students experienced the learning environment that was based on the conjectures and principles formulated during this study, a sample was selected from the student population using a random sampling method. White (2005, p. 118) proposes that a simple random sampling technique include any method "that provides each population element an equal probability of being included in the sample". Each student in the population was assigned a number and then a table of random numbers (ibid. p. 121) was used to select two focus groups of eight participants each.

The population consisted of 140 students from the Tshwane University of technology who were enrolled for a diploma course in Information Communication Technology and registered for the Foundation English Communications Skills subject. The contact sessions were held at the Soshanguve South campus of the Tshwane University of Technology (TUT).

3.5 Data collection

Focus group interviews, held with the samples described in 3.4.1 and 3.4.2, were principally used as a data-collection instrument in order to gain comprehensive insight into their opinions and experiences. Focus group interviews are "semi-structured discussions" with groups of between 4 and 12 people for the purpose of exploring a particular set of issues (Tong, Sainsbury & Craig 2007, p. 351). It is good practice to ask broad questions related to the topic of the discussion initially before focusing on questions that are more pertinent to the study (ibid.). During focus group interviews participants are encouraged to interact with one another but the facilitator must ensure that they answer questions individually (ibid.). This interaction would allow respondents to "explore and clarify individual and shared perspectives" (ibid.).

Tremblay, Hevner and Berndt (2010, p. 600) propose two types of focus group in design-based research; these are "exploratory focus groups" that are used for the "design and refinement of an artefact" and "confirmatory focus groups" (ibid.) that are used to explore or confirm an artefact's value in an authentic setting. They consider focus group interviews to be an "appropriate evaluation technique for design research projects" for the following reasons:

- Focus group interviews are sufficiently flexible to accommodate a "wide range of design topics and domains".
- The researcher is placed in direct contact with potential users of the designed artefact as well as with domain experts. This enables the

researcher to obtain clarity concerning the designed artefact as well as pertinent design issues.

- Focus group interviews yield rich data that allows the researcher to gain a comprehensive understanding of issues discussed.
- Focus group interviews enable respondents to build on the comments of others (ibid.).

Ten focus group interviews were conducted with members of the design team and four focus group sessions, two per group, were conducted with the sample drawn from the student population. The ten focus group sessions conducted with the design team were held at the Pretoria West campus of the Tshwane University of Technology from 20 January 2011 to 4 March 2011. A relaxed and informal atmosphere was created during each of these focus group sessions where participants were free to help themselves to refreshments at any time during the interview. Each of the focus group interviews lasted between twenty and thirty-five minutes and on rare occasions certain group members were required to excuse themselves during the interview due to lecturing commitments. The researcher facilitated the focus group interviews and typically opened each session with very broad questions such as: *How did you experience what we did today?* Or, *What are your thoughts concerning what you experienced during this session?* The questions became more focused as ideas and opinions emerged from the discussions. Each of these interviews was recorded using a handheld cassette recorder; these recordings were later transcribed verbatim in preparation for analysis.

The focus group interviews conducted with the student sample were held at the Soshanguve South campus of the Tshwane University of Technology between April 2011 and June 2011. These focus group interviews were conducted midway through training and then again at the end of training. A relaxed atmosphere was created before each of the focus group sessions where the researcher reminded the students of the purpose of the research and that participation was completely voluntary. None of the students elected

to leave and all of them approached the interviews with enthusiasm and a willingness to be included in the undertaking. The researcher facilitated the focus group interviews and initially used very general questions such as: *What are your impressions of the learning environment that we have been working in over the last few weeks?* Or, *How do you experience working in the learning environment*? These questions became more specific as ideas, opinions and experiences were expressed. Each of these focus group interviews was recorded using a handheld cassette recorder; these recordings were later transcribed verbatim in preparation for data analysis.

3.6 Data analysis

The data analysis of both sets of focus group interview transcriptions was undertaken using the grounded theory method of coding, sorting and analysing. The Computer-Assisted Qualitative Data Analysis Software application (CAQDAS), Atlas.ti, was used in order to make the analysis more versatile.

3.6.1 The use of Atlas.ti in preparing for data analysis

Making use of 'code and retrieve' software such as Atlas.ti inevitably allows a researcher to include much larger quantities of data in the research and makes the coding process "significantly less cumbersome and tedious" (Lu & Shulman 2008, p. 106). Using CAQDAS allowed the researcher to invest more mental energy in the analysis rather than in the technicalities and logistics of the research process (ibid.). Atlas.ti was used during the data analysis stage of this study to assist in the examination and interpretation of the focus group interviews described in paragraph 3.5. Each of the transcripts of the focus group interviews conducted with the design team was imported into the Atlas.ti environment separately as a primary document. Consequently there were ten separate hermeneutic units, separate Atlas.ti projects, involved in the analysis of the design team focus group interviews. This was done to preserve the context of each of the design sessions during the data analysis,

which assisted the researcher in making sense of comments made by the members of the focus group.

Transcripts of all four of the focus group interviews held with the student sample were used as primary documents in the Atlas.ti environment to create a single hermeneutic unit to explore how students experienced the learning environment.

3.6.2 How the design team focus group transcripts were analysed

The analysis of the transcripts of all focus group interviews was based on the grounded theory method. This “consists of flexible strategies for focusing and expediting qualitative data collection and analysis" (Charmaz 2001, p. 675). The transcripts of focus group interviews held with the design team were coded using the software application Atlas.ti. (See Appendix F). Open coding was done, predominantly using a full sentence as the unit of analysis but fragments were also coded when this was considered appropriate. From time to time more than one sentence was grouped together under a single code when these together contained a discrete idea. This is in keeping with Zhang and Wildemuth's (2009, p. 3) assertion that qualitative content analysis typically uses "individual themes as the unit for analysis" that are not necessarily expressed in "physical linguistic units". The occurrence of a theme could be "expressed in a single word, a phrase, a sentence, a paragraph, or an entire document" (ibid.). Mainly descriptive labels were used during this phase of the coding process and often the words used by participants were used as labels. This is referred to as "in-vivo" in the Atlas.ti environment. Glaser (2002, p. 24) suggests that concepts are "in-vivo" when "they come from the words of the participants in the substantive area". Once this initial labelling had been done, and through a process of constant comparison, codes that contained similar central features or characteristics were grouped together to form more abstract higher-level categories. For instance, the higher-level category 'discovery learning' is made up of the following codes:

- Build on basic knowledge

- Trial and error
- Apply learning
- Battling on your own
- Sequence
- Hands on

These lower-level codes all seem to contain characteristics of discovery learning as a central idea or at least as a significant theme. It was commonly the case that a single low-level code was grouped more than once under a higher-level code or category. These codes were grouped together in "code families" using Atlas.ti. These code families were printed and then arranged in a table that has the following headings: category, codes, quote to support creation of category and comment (See Addendum A). This helped to establish groundedness and at times highlighted the necessity to regroup or rename codes/categories. The principle of constant comparison was central to this process. Wasserman, Clair and Wilson (2009, p. 359) point out that "the process of constant comparison brings data specific codes and broader concepts into an insight generating dialogue, as opposed to a simple grouping process".

To facilitate the formulation of design principles in the form of conjectures and principles, the format developed by Van den Akker (quoted in Plomp 2007, p. 17) in order to devise heuristic statements that are characteristic of design principles, was broken down into discrete parts. These parts were labelled ‘characteristics (substantive emphasis)’, ‘procedures (procedural emphasis)’ and ‘arguments’. A table was then designed using ‘category/codes’, ‘emergent characteristics (substantive emphasis’, ‘emergent procedures (procedural emphasis)’ and ‘emergent arguments’ as headings for each column. (See tables 4.3-4.9, pages 166-212). The table formulated to establish or identify higher-level or more abstract categories was then closely examined in order to identify the emergent characteristics, procedures and arguments associated with each category. These emergent characteristics, procedures and arguments were organised in the appropriate table without regard for repetition, relevance or significance. Once all the higher-level categories

formulated during the open coding process had been examined and organised in the table previously described, a process of reorganisation was undertaken. Design principles that could rationally be related to one another were grouped under the following headings:

- Initial exposure to the learning environment
- Handouts
- Discovery learning
- Design
- Subject (domain) awareness
- Representing understanding
- Development
- Problem interaction
- Sequence
- Scaffolding
- Examples

This reorganisation and grouping facilitated the filtering out of repetition and the discarding of principles that were considered insignificant and irrelevant. These reorganised characteristics, procedures and arguments were once again organised in a table with similar headings to the table described above but this time the design principles contained in it were not considered to be simply emergent from the data (See Appendix D). Once this table was complete descriptive paragraphs were formulated under the same headings mentioned above. This allowed for the relationship between the characteristics, procedures and arguments to be more clearly represented or articulated.

The process of identifying emergent characteristics, procedures and arguments, based on Van der Akker's heuristic formulation guidelines (quoted in Plomp 2007, p. 17), replaced the axial and selective coding stages more typically associated with grounded theory.

3.6.3 The process of analysing the student samples' focus group transcripts

Open, axial and selective coding techniques were employed in the coding, sorting and analysis of the transcripts of focus group interviews held with the sample drawn from the student population.

3.6.3.1 Open coding

De Vos *et al.* (2009, p. 341) propose that open coding involve the “naming and categorising of phenomena through close examination of the data". This basically involves "breaking down the data and identifying concepts embedded within individual statements" (Wasserman *et al.* 2009, p. 359). Transcripts of the focus group interviews that were held with the students were coded using Atlas.ti. The open coding was done in the same manner as described in 3.6.2. Once this initial labelling had been done, and through a process of constant comparison, codes that contained similar central features or characteristics were grouped together to form more abstract higher-level categories. For instance, the following descriptive labels or lower-level categories:

- Disagreement encourages thinking
- Have to think (reflect)
- Thinking logically
- Open mind
- Moving out of comfort zone
- Exploring own ideas
- Thinking at a higher-level
- Thinking like experts
- Thinking outside the box
- Understand the problem

were grouped under the higher-level code "thinking at a higher level [*sic*]" because they all had thinking more deeply or in a way that was not routine for the students as a central idea or characteristic. It was commonly the case that a single low-level code was grouped more than once under a higher-level code or category. For instance the lower-level code, "Disagreement encourages thinking", was grouped under the higher-level category "Thinking at a higher level [*sic*]" as well as under the higher-level category "Collaborating in groups".

All codes and categories identified during the initial stage of the open coding process were grouped together in "code families" using Atlas.ti. These code families were printed and then arranged in a table that has the following headings: category, codes, quote to support creation of category and comment. This helped to establish groundedness and at times highlighted the necessity to regroup or rename codes/categories.

3.6.3.2 Axial coding

Axial coding is a process that involves reassembling data in new ways after it has been fragmented during the open coding phase of the data analysis process (De Vos *et al.* 2009, p. 343). The relationship between the higher-order codes/categories and their related lower-order categories and codes were explored during the axial coding phase. A thorough analysis was performed around a single category at a time primarily with reference to the coding paradigm outlined by Corbin and Strauss (1990, pp. 423-424). Causal conditions that gave rise to the occurrence of the category/phenomenon were investigated, the phenomena themselves were established, attributes of the context were explored by examining the set of facts or circumstances that surrounded the phenomena, intervening conditions were investigated, action/interaction strategies that were formulated by the actors to handle the phenomena were explored and the consequences of these strategies were taken into consideration during this phase of coding.

For instance, intense analysis was performed around the higher-level code/category/phenomenon, "disagreement among group members". What caused this phenomenon to come about were the "group assignment" and the "different ideas" that were generated in the group. The circumstances that surrounded this phenomenon were the learning environment (i.e. laboratory sessions, non-laboratory sessions) and group discussions. The action/interaction strategies that students employed to handle the phenomena were mainly centred around attempts to "convince group members"," group decision making (vote)" and reflecting on one's own ideas. The consequences of these strategies were that "disagreement encourages thinking" and "leads to better end results" as well as "not getting the job done".

3.6.3.3 Selective coding

The main idea that emerged during the open and axial coding phases was centred on *working in a learning environment that uses technology as a cognitive tool*. All other categories were related to this core concept. The process employed to refine the description of how students experienced the learning environment that uses technology in the form of an expert system shell to facilitate higher-order thinking made use of several overlapping steps. These involved an explication of the story line, in which a general description of how the students experienced the learning environment is outlined. Evans (2007, p. 202) proposes that it is while explicating the story line that the researcher develops a story that "brings together the majority" of the elements uncovered during the research. Ideally only one core category should emerge.

A relationship between categories at a dimensional level as well as the way in which the categories relate to the core category was then outlined. Evans (2007, p. 202) suggests that this step involve "asking questions and making comparisons" of and between the categories and codes uncovered.

The relationships between categories were validated against the data by extracting salient quotations from transcripts of the focus group interviews held with the student group and incorporating them in a descriptive passage.

The quotations extracted from the focus groups interviews held with the student group are presented according to the following example:

FG 1.4.5:

Like we learn what our managers out there in the business world expect from us.

The numbering of the quotation can be decoded as follows:

- FG 1 indicates that the quotation is from the first focus group interview.
- 4 indicates that it was the fourth respondent who spoke during that interview.
- 5 indicates that it was the fifth individual quotation in that focus group's transcript.

The previously mentioned steps were not seen as distinct from one another but together allowed for the development of an analytic story. This analytic story was outlined in a descriptive passage (see Table 4.11).

3.7 Trustworthiness of the research findings and analysis

In conventional positivist research, quality is assessed by using validity, reliability and objectivity as criteria (Zhang & Wildemuth 2009, p. 6). Due to its interpretative nature the validity of "qualitative content analysis" cannot be assessed using the same set of criteria (ibid.). Creswell and Miller (2000, p. 126) indicate that the "validity procedures reflected" in constructivist thinking "present criteria with labels distinct from quantitative approaches such as trustworthiness" (ibid.). Gasson (2004, p. 89) points out that trustworthiness in qualitative research revolves around Lincoln and Guba's ideas concerning dependability, confirmability, transferability and credibility. The trustworthiness of this study will now be discussed with reference to its dependability, confirmability, transferability and credibility.

3.7.1 Dependability

Gasson (2004, p. 94) proposes that clear and repeatable procedures concerning the manner in which we conduct the research be required to ensure the dependability of findings. She suggests that "making explicit the process through which findings are derived is a useful way of ensuring their dependability". This is supported by Zhang and Wildemuth (2009, p. 7) who indicate that to establish dependability the "consistency of the study processes" needs to be demonstrated. The following guidelines are proposed by Gasson (2004, p. 94) in order to establish dependability:

- Procedures employed to collect and analyse data should be defined.
- The ends that these procedures achieve should be articulated.
- Record these procedures so that others will be able to understand them.

An in-depth description of all methods used to collect and analyse data is provided to allow for the "integrity of research results to be scrutinised" (Shenton 2004, p. 73).

3.7.2 Confirmability

Confirmability is ascertained by examining the "internal coherence of the research product", which is made up of "the data, the findings, the interpretations, and the recommendations" (Zhang & Wildemuth 2009, p. 7). Gasson (2004, p. 93) proposes that distortions regarding confirmability be minimised by the researcher making explicit assumptions and frameworks regarding research findings. A theoretical framework together with a discussion and literature reflection (see 4.5) was conducted in order to make explicit the assumptions and frameworks applicable to the research findings.

3.7.3 Transferability

Transferability involves the degree to "which the researcher's working hypothesis can be applied to another context" (Zhang & Wildemuth 2009, p. 6). Gasson (2004, p. 97) indicates that the constant comparison method of data analysis can go some way toward establishing transferability and credibility. Findings were constantly compared to one another during the analysis stage of the study in order to establish categories and themes. Background information together with a theoretical framework on which the study was based was also provided in order to improve transferability to other contexts.

3.7.4 Credibility

Credibility concerns the assurance that the study "measures or tests what is actually intended" (Shenton 2004, p. 64). The following "provisions" are proposed by Shenton (ibid.) in order to promote confidence that the researcher has "accurately recorded the phenomena under scrutiny":

- using well established research methods
- random sampling
- techniques to encourage honest responses from participants (encouraged to be frank, opportunity for refusal, involve only those genuinely willing to take part, establish a report, right to withdraw at any time without disclosing a reason)
- "frequent debriefing sessions"
- "peer scrutiny of research project"
- reflective commentary by the researcher
- "member checks"
- thick "descriptions of the phenomenon under scrutiny"
- examining previous research findings.

Wimmer and Dominick (2006, p. 120) point out that leaving an "audit trail" would "help build credibility". An audit trail is a "permanent record of the original data used for analysis and the researcher's comments and analysis methods" (ibid.). By leaving and audit trail, others will be able to evaluate the researcher's thought processes and, in so doing, assess the accuracy of conclusions reached (ibid.).

In order to ensure credibility this study employed well-established research methods that the literature suggested were suited to research into computer technology-assisted learning interventions. Though purposive sampling was used to select the lecturers and instructional designers that made up the design team, random sampling was used to select focus group participants from the student population. To encourage honest responses from participants from both the design team and student sample focus group interviews, the following techniques were employed:

- A suitable rapport was established between all participants and the researcher who acted as facilitator during the focus group interviews.
- All participants were encouraged to be frank and forthright during focus group discussions.
- All participants were given the opportunity to refuse to participate at any time during the study.
- All participants were given the opportunity to withdraw from the study at any time during the study without any repercussions to themselves and without giving reasons for doing so.

Debriefing sessions, outlining themes and ideas that emerged from previous meetings, were conducted at the beginning of each meeting with the design team. Members were invited to comment on these to ensure accuracy. During the data analysis phase of the research the researcher constantly undertook a process of reflective commentary in the form of memoranda (see Addendum A). The researcher constantly reflected on the literature during the analysis

phase of the research to identify parallels and to facilitate the accurate interpretation of findings.

Before a description of any of the conjectures and principles relating to the learning environment is presented, the data collection and analysis methods are outlined. In an attempt to leave a thorough audit trail, all tables on which the descriptions of the conjectures and principles are based are included when research findings are discussed.

3.8 Ethical considerations

The ethical considerations applicable to this study involved informed consent, voluntary participation and the avoidance of harm.

3.8.1 Informed consent

Informed consent is a consistent and indispensable aspect of qualitative research and involves providing participants with "accurate and complete information" that would allow participants to gain a complete understanding of the study (De Vos *et al*. 2009, p. 59). As a consequence of this information they should be in a position to make a "voluntary, thoroughly reasoned decision" concerning possible participation (ibid.). Information regarding this study was provided to the design team as well as to the student sample. A research participation information sheet was prepared and made available to the student sample (see Addendum B) as well as to the design team (see Addendum C). It was made clear to all participants that they were free to ask any questions and they were asked to complete a checklist that had been designed to ensure that they completely understood the nature of their involvement in the study (see Addendum D).

3.8.2 Voluntary participation

Participants from both the student population as well as those that made up the design team were made aware that their participation in the research was

completely voluntary and that they could withdraw from the study at any time without having to provide reasons. They were assured that their withdrawal from the study would have no consequences.

3.8.3 Avoidance of harm

Avoidance of harm involves taking steps to ensure that participants are not "harmed in a physical and/or emotional manner" (De Vos *et al*. 2009, p. 58). This study did not involve any harmful physical activity or emotionally hazardous conduct.